RADIO and ELECTRONICS

Vol. 4, No. 1 1st April, 1949

Contents Page

OUR COVER:

This month's cover illustrates the original of the "Radel" Economy 10-watt Amplifier, the circuit of which was published in our last issue. This issue contains constructional details, chassis diagram, and further photographs of this amplifier Please see page 13.

A CHANGE IN DATES

As from the next issue, "Radio and Electronics" will be on sale approximately a week earlier in the month than it has been in the past. The next issue, instead of being called the May, 1949, issue, will be marked the "Easter, 1949," issue, and the one after that the May issue. We will then be in the more satisfactory position that the journal will appear in the first week of the month, dated for that month. This does not mean that we are missing an issue, or that there will be two issues published in one month. All that will have been done is to change the titling of all issues after the present one.

CORRESPONDENCE

All correspondence, contributions, and enquiries referring to advertising space and rates should be addressed to:—

The Editor,
"Radio and Electronics,"
Box 22,
Government Buildings P.O
WELLINGTON.

OFFICES AND LABORATORY:
Radio and Electronics (N.Z.) Ltd.,
46 Mercer Street, Wellington.

TELEPHONE:
Wellington 44-919.

AUCKLAND REPRESENTATIVE:
Mr. J. Kirk,
No. 11 Keans Building,
150 Queen St., Auckland.
Telephone 48-113. P.O. Box 401.

AUSTRALIAN DISTRIBUTORS:
Messrs. Gordon & Gotch (A/sia.) Ltd.

Remittances from Australia to New Zealand should be by international money orders or bank draft payable in New Zealand.

Sole Wholesale N.Z. Distributors FEATURE PRODUCTIONS LTD., P.O. Box 5065, Wellington.

Printed in New Zealand by H. H. Tombs, Ltd., Wingfield Street, Wellington.

THE S-METER—IS IT WORTH IT?

According to commonly accepted definition, a meter is a device which is capable of making numerical indications of the value of some quantity which itself can be expressed in numerical units of some kind. Thus, in order to use a meter, the quantity, or thing which it is to measure, must be able to be expressed in numerical units, which themselves can be rigidly defined. Our electrical units, such as the ampere, the volt, and the ohm, are such units, so that it is possible to make arrangements for measuring them.

The S-meter, however, is that strange phenomenon, a meter without a unit. At this point, there are probably many who will say: "This is not true; the S-meter measures S-units." But what is an S-unit? It certainly cannot be found among the tables of electrical units to be seen in the better text-books. It is popularly supposed to be a unit of signal strength, of course, but simply calling it so cannot legitimize a "unit" that is of exceedingly doubtful parentage! We have always been somewhat astonished at the rather touching faith placed in S-meters, and our reason for doing so is to be found here.

Let us consider for a moment just what, if anything, the S-meter measures. In the first place, it is a device which can be attached to any receiver, within limits. It can have any desired circuit, as long as it fulfils one condition—namely, that it indicates the presence of a signal in the receiver and at the same time can discriminate in some way between signals of different strength. Now, because there is no standard receiver, it is quite impossible to predict what reading a meter of this sort will give when the signal has a known strength in microvolts. If we were to be able to do this, it would be necessary to have a receiver in which the sensitivity was known in terms of, say, plate current in the stage operating the meter, for a given signal strength at the aerial terminal, but this would not be all. In order to relate a number of different signal strengths at the aerial to readings on the meter, it would be necessary to know exactly the A.V.C. characteristic of the receiver. It would then be possible to calibrate the meter in terms of signal strength at the aerial terminal. But what of S-units? Until someone came forward with a universally accepted proposal that, in the standard receiver we have described, a certain number of microvolts at the aerial should represent S_1, and that every so many decibels above this level would increase the reading by one S-unit, it would be quite impossible to relate the S-numbers given by one receiver to those given by another.

All this has detailed a method whereby a STANDARD S-meter circuit could be made to mean something when attached to a STANDARD receiver, which indicates how difficult the problem is and just how little the readings mean of an S-meter of any description, attached to a receiver of any description. But suppose that by some species of regimentation it has been arranged that everyone who is desirous of using an S-meter shall have one of these standard receivers, fitted with the standard meter circuit. We are very little better off even now, because every user of the receiver will have a different aerial, which will deliver a different number of microvolts to the aerial terminal for the same R.F. field.

In short, there is only one way in which the strength of a signal at a given place can be evaluated, and that is by meansof a proper measurement of field strength in microvolts per metre. This is clearly not feasible, because to do so requires very expensive equipment and takes time to do, even assuming that the equipment is there.

The attempt to put signal-strength reporting on a firmer basis than that of aural estimation was in the first place a laudable one, but it has not succeeded, and one of the chief difficulties is that it has been commercialized by receiver manufacturers who should have known better than to subscribe to a piece of technical misrepresentation, however unintentional and however desirous the radio community may have been of being convinced that there was something in it

A New Low-Noise Triode Mixer Circuit

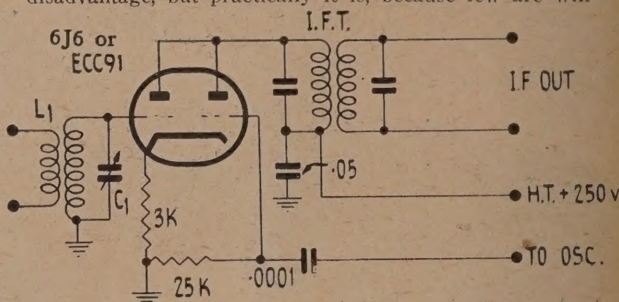
In 1946, "Radio and Electronics," then in its infancy, presented a triode superhet. mixer circuit which has become very widely used in this country under the name of the Infinite Impedance Mixer. This circuit has enabled very low valve noise to be achieved in high-frequency receivers, which accounts for its great popularity among amateur transmitters and others. The circuit to be described here has advantages over the infinite impedance mixer, and should allow of even better performance.

Introduction

When this journal began, in early 1946, relatively little had been heard by many amateurs about the design of receivers for the best possible signal-to-noise ratio. The subject is one which achieved great prominence during the war, because of its importance in radar receivers, where an increase of signal-to-noise ratio means increased range, comparable with that obtained by increasing the transmitted power by a factor equal to the improvement in signal-to-noise ratio at the receiver. Commercial designers of communications receivers had done nothing to provide a low-noise receiver apart from putting in one or more stages of R.F. amplification, on the principle that when this had been done, no further worth-while improvement was possible, within economic limits. Since the sets referred to did not often use valves in the first R.F. stage which were notable for their lack of noise, the result was often no better, from the signal-to-noise point of view, than other manufacturers were achieving in ordinary allwave receivers. In addition to this, the amateur radio literature had not seen fit to recommend any low-noise circuitry for the high-frequency receivers described periodically in it. Thus, when a triode mixer was substituted for conventional multi-grid tubes such as 6A8, 6K8, 6SA7, 6L7, etc., even where one or two R.F. stages were in use also, the result in a great number of cases was an improvement in signal-to-noise ratio so great as to be noticeable by ear. This certainly enabled weaker signals to be copied than was the case beforehand, and the circuit was hailed with considerable delight by a large number of our readers. Others, of course, were convinced only by the glowing reports of their friends and acquaintances, and ultimately became converts to the triode mixer in general and the so-called infinite-impedance mixer circuit in particular. There still remain the really hardened sceptics, but at this late date the only assumption that can be made is that these do not want a better receiver anyway!

Now, in our original article, no claims were made that the use of a triode mixer is the final answer to all signal-to-noise ratio problems. It was stated, however, that, unless care was taken, the addition of an R.F. stage to a receiver which already has an infinite impedance mixer is likely to *degrade* the signal-to-noise ratio rather than to improve it. This has subsequently been shown to be true in a number of cases, where measurements were made on receivers which had identical circuits except for the fact that one was without an R.F. stage, while the other had a stage using an ordinary pentode, such as the 6K7, as an R.F. amplifier. Measurements have also shown that in the 30 mc/sec. region, a receiver whose first valve is an infinite impedance mixer is only very slightly improved, if at all, by the addition of a low-noise R.F. stage employing a 6AK5. It would seem from this that as far as noise contributed by the mixer is concerned, at frequencies up to 30 mc/sec., a very great improvement is realized by the use of the infinite impedance mixer circuit, and that it is thus not very profitable to strive for further improvement still. However, the infinite impedance circuit has its limitations, and the circuit presented here represents, on theoretical grounds to say the least, some improvement upon it.

What, then, are these limitations? First of all (and this is a point about which there seems to be a good deal of misapprehension), the conversion gain of the infinite impedance mixer is very low compared with that of the conventional mixer valves which it supplants. This means that in a set which has no R.F. stage, the signal-to-noise ratio can be, and often is, determined by the noise generated at the grid of the first I.F. stage. Thus, in order to take full advantage of the infinite impedance mixer, it is advisable to have a low-noise type of tube as the first I.F. amplifier. Now, since the mixer circuit itself is unable to be controlled by A.V.C., and since high-G_m, low-noise pentodes are not very suitable for A.V.C. control either, this means that there is considerable difficulty in providing such a set with a good A.V.C. characteristic. Theoretically, this is not much of a disadvantage, but practically it is, because few are will-



Circuit of the new mixer. Note that the values refer only to the valve types mentioned in the diagram.

ing to forgo the convenience of a set with good A.V.C. action and return to the use of a manual gain control.

Many people have criticized the infinite impedance circuit on the score of its low conversion gain, but for an entirely wrong reason. The one usually given is that the overall gain of the receiver is much lower than it should be. As we have been at pains to point out on a number of occasions, amplification, for its own sake, is no use at all, since, although it is possible to achieve as much of it as we please, we can not make use of it unless we have first established a good ratio of signal to noise. There is always an irreducible minimum of set noise, however small, and as long as the overall gain of the receiver is great enough to bring this noise level up to audibility, then the best performance of which the set is capable will be realized. In comparatively low-gain circuits, it is possible to arrive at the situation where the overall gain is not great enough to do this, after the infinite impedance mixer circuit has been substituted for the original mixer, but this is the only case where the low conversion gain matters very much. However, the circuit presented in this article has been found to have a considerably higher conversion gain than the infinite impedance mixer circuit, and those who complain (whether rightly or wrongly) about the low stage gain of the

former circuit will have a greater liking for it on that account.

A further disadvantage of the infinite impedance mixer circuit is that it sometimes exhibits a tendency towards instability. This has been attributed to the high plate resistance exhibited by the triode valve because of the conditions under which it works in that circuit. Experiments have shown that the effective plate resistance can be higher than that of a pentode acting as a mixer under conditions similar to those of a pentode biased detector. This causes the loading on the primary winding of the I.F. transformer into which it works to be much less than is normal, with the result that any incipient instability *in the I.F. amplifier itself* is brought into prominence. For example, the slight amount of loading caused by the mixer plate circuit is often just sufficient to hold the I.F. amplifier down, so that when the infinite impedance mixer circuit is substituted for an existing mixer circuit, instability occurs. This is not really attributable to the mixer circuit itself, and could be cured by improving the inherent stability of the I.F. amplifier, but the effect is the same as if the mixer itself were the offender.

Another cause of instability, and this time one which can definitely be charged against the mixer itself, is cathode-follower oscillation of the mixer valve. It is well known that the cathode-follower circuit can oscillate and that if the cathode load impedance becomes capacitative, the circuit is regenerative. This type of oscillation can therefore occur in any circuit in which an unbypassed cathode resistor is used. Valves with a high mutual conductance are more susceptible to this type of instability than those with a low G_m, and when an attempt is made to operate a high-G_m triode as an infinite impedance mixer, by placing a very high resistor in its cathode circuit, it is prone to give this kind of trouble.

How Can the Infinite-Impedance Mixer be Improved?

All this is very well in its way, but the question now arises: "Can the infinite-impedance mixer circuit be improved upon?" the purpose of this article is to show that, without doubt, it can. In the first place, although it has a very much lower noise level than that of multi-grid converter valves, it is susceptible to still further improvement in this respect. In general, it is correct to state that the equivalent noise resistance of a triode is lower the greater the mutual conductance. Now, the mutual conductance referred to is not necessarily the one quoted in the valve data books, since the important figure is the mutual conductance under working conditions. Thus, if we can find some means of increasing the G_m of the mixer triode, we will have decreased the mixer valve noise. One obvious way of attempting this is simply to use a valve which has a higher rated G_m than the tubes we have already been using.

For example, a tube which has been used a number of times is the 6SN7, one section as the triode mixer and the other as the oscillator. Each section of this valve has a rated G_m of 2.6 ma/v. at a representative plate voltage and grid bias. The 6J6, on the other hand, has a rated G_m of 5.3 ma/v. for each section. It might therefore be argued that the latter valve, with both sections in parallel, and used as a mixer, should have 10.6/2.6 = 4.1 times the conversion gain of the 6SN7, if circuit conditions are altered to suit the increased mutual conductance. Tests were therefore undertaken to see if this idea could not be worked out in practice. As a starting point, a cathode resistor of 10,000 ohms was used. At this, the circuit functioned, but the signal-to-noise ratio was found, if anything, to be inferior to that of the earlier circuit using the low-G_m tube. From this, it was inferred that the conversion conductance was too low, in spite of the use of the high-G_m valve. An obvious method of attack from this point was to decrease the cathode load resistor, allowing the valve to pass more plate current, and therefore to have a higher effective mutual conductance. Tests showed that a value of 3000 ohms was the optimum, and that the oscillator voltage injected into the second grid, as shown in the circuit diagram, was not at all critical. Nor, for that matter, was the value of cathode resistor, the maximum conversion gain showing a broad maximum. This is to be expected, since the operating conditions are dependent not only on the value of cathode resistor but also on the amount of oscillator voltage injected. For example, as long as the oscillator swing is such that a large portion of the grid characteristic is covered by it, without driving the valve into grid current, then the average mutual conductance will not depend on the cathode resistor very much, within limits. However, the bias provided by the cathode resistor should not be too small, for if it is, there is a danger that the positive half-cycles of the oscillator voltage will drive the valve into grid current. This would cause the input impedance to be low, as it would damp the input tuned circuit, and this is clearly to be avoided.

Buffering Action

The circuit finally arrived at as being the best from all points of view is the one shown in the diagram. Here, a separate oscillator is necessary, since the 6J6 has only one cathode, common to both sections; the oscillator circuit has not been shown, because any normal kind of oscillator can be used with equal success. The signal is applied through a tuned circuit, in the usual way, to one grid. The plates are connected in parallel and the other grid is used as an injection grid. It is possible to economize on components by connecting the oscillator grid directly to the injection grid, doing away with the leak and blocking condenser shown on the circuit diagram. Alternatively, the terminal marked "To Osc." can be connected to any suitable part of the oscillator circuit, such as the plate in an ordinary tickler-feedback type of circuit, or to the cathode tap in a Hartley oscillator. A different arrangement was shown in the "Junior Communications Receiver," which was described in recent issues of this journal. In this, the injection grid was connected directly to the tap on the modified Hartley oscillator. Any of these schemes will be found to work well.

Since the plate current of the 6J6 mixer is much higher than in the infinite impedance circuit, the plate resistance is a good deal lower. This enables the I.F. amplifier to "sit down" quite well without shunting the primary of the first I.F. transformer so much that the tuning of this winding is unduly broadened. It will be found to peak up quite sharply.

Feeding the oscillator voltage into the circuit in this way provides a degree of buffering action, partially isolating the signal circuit from the oscillator. With a 1600 k/sec. intermediate frequency, the oscillator pulling was found to be very slight. This was so even with the oscillator tuning not ganged to the signal-frequency tuning, in which case any pulling that occurs is most noticeable. At 30 mc/sec. variation of the input tuning was found to influence the oscillator frequency only slightly, as shown by the fact that with the B.F.O. switched on, the change in beat note as the input circuit was tuned through resonance was only a few cycles per second.

It was thought that better buffering would be given by operating the second section of the valve as a cathode follower. This can be done simply by taking the plate of the section whose grid is used for oscillator injection directly to H.T., instead of paralleling it with the mixer

plate. It was found, however, that this arrangement was not so satisfactory as the one illustrated. This was because there was a distinct tendency, even at low-signal frequencies, for the cathode-follower section to go into oscillation on its own account. At high frequencies, stable operation was almost impossible to obtain.

Conversion Gain

Measurements of the conversion gain of the whole circuit were made after initial tests had shown that the circuit gave promising results. The system was installed in the Junior Communications Receiver, already referred to, and measurements taken as follows. The signal generator was fed into the grid of the first I.F. stage, at its frequency of 1600 kc/sec., and the attenuator reading noted for a particular output reading on the output meter. Then the signal generator was transferred to the aerial terminal, its frequency altered to the required signal frequency, and the input tuning control tuned for maximum response. The attenuator was then re-set so as to give the same output reading as was used before, and the setting noted. The ratio between the two attenuator readings is then the conversion gain of the circuit. Some of this is due to the aerial coil, and the figure obtained does not therefore apply to the valve alone, but this cannot be helped. If the attenuator were connected directly at the grid of the 6J6, the operating conditions would be altered, and the figure thus obtained would bear no simple relationship to the gain when the tuned circuit is attached to the grid. The figures would therefore be meaningless. The results of these tests showed that the conversion gain from aerial terminal to first I.F. grid varied between 14.5 and 16.5 over the range 3 to 30 mc/sec. This is somewhat lower than one gets in measuring the conversion gain of a conventional mixer valve in a similar way, but is considerably more than is shown by the older infinite impedance mixer.

Signal-to-Noise Ratio

As yet, no figures are available on the noise-factor of a receiver using this new mixer circuit. This is unfortunate, as it would have been a good thing to quote such figures in support of our argument above on the signal-to-noise ratio of this mixer. We hope to be able to carry out some comparative work shortly and to obtain figures showing the results obtained with this circuit, alongside those for the infinite impedance mixer and other more conventional types.

However, on evidence solely connected with the valve types, and on the fact that the new circuit is working somewhere near the best possible conditions, as against the infinite impedance mixer, which is not, it can be shown that the new circuit should be at least 6 db. better than the old one, with a strong probability that the difference is greater still, in favour of the new circuit.

Results to be Expected

Those who already have the infinite impedance mixer in operation *without* a preceding R.F. stage, can be expected to obtain a noticeable improvement in signal-to-noise ratio if they substitute the new circuit for the old. In the case of a set with an infinite impedance *and* an R.F. stage, the improvement will not be so noticeable, and in cases where a very efficient R.F. stage is used, there may hardly be any effect. However, the overall gain will be increased, and the important point to remember is that this increase will not bring with it any *reduction* in the signal-to-noise ratio of the receiver. Those who will notice the greatest benefits are those who substitute this circuit for one which uses a 6K8, ECH5, or similar tube, whether or not the set already has an R.F. stage.

We were listening on the 80-metre amateur band the other day, and heard a conversation that went something like this: "Very nice about your receiver with the infinite impedance mixer, O.M.; I've heard a lot about these receivers that are so quiet that with the gain full on you can't hear a sound, and when a signal comes along it just about blows the speaker out into the room, but I haven't heard one yet, and I don't know that I ever will."

Now there is a moral in this. It is that the gentleman concerned was both right and wrong at the same time. It *is* possible to build such a set, but if you have one it simply means that the amplification is not great enough to allow full advantage to be taken of the excellently low set noise. This does not mean that such a set is a bad one. It simply means that the signal-to-noise ratio is such that more useful gain could be incorporated. Now, suppose we have a set like this, and we take out its low-noise mixer and substitute a 6K8. Two things will happen. First, the amplification will be increased, and secondly, the set noise will increase. Both these factors together will probably mean that the set noise is now clearly audible. If this is the case, then the set's amplification is high enough, for however much more gain we might add to it, it will not allow us to hear any weaker stations than it would originally receive. Therefore, if you use the present circuit to pep up the signal-to-noise ratio of an existing receiver and find in consequence that the set noise is only barely audible after the conversion, you can usefully add more gain by putting in a high-gain I.F. stage, or simply by adding audio gain; which, does not matter.

At the other end of the scale are those who put a low-noise converter, using, say, our triode mixer circuit, and a stage of high-frequency I.F., in front of a set. Now, the characteristics of the converter circuit determine the signal-to-noise ratio possessed by the whole arrangement, and since the converter has a large voltage gain, on account of the I.F. stage incorporated therein, the net observed result is a great *increase of noise* when that arrangement is hitched on to the main receiver. Often and often this has been done, and the builder has been disappointed, saying that he now has much more noise than he had before. What he should remember is that *the loudness of the noise heard at a given gain setting depends as much on the overall gain as on the signal-to-noise ratio.* For this reason, *there is no connection between the amount of noise that comes out of the set and the signal-to-noise ratio of the receiver.*

In other words, however little noise the first circuit and valve produce, the set can never be quite noiseless, since there is an irreducible minimum of noise; and the gain a set should have depends solely on how much is needed to make this minimum clearly audible. *It is quite impossible to estimate, even roughly, the noise performance of a receiver from the amount of noise it can make when no signal is present.* The important thing is what happens to a signal of a *known strength* when dealt with by the receiver, and the only way of making a comparison between two sets is to see how each performs with the same signal applied to it as to the other. Of course, if a calibrated noise generator is available, the noise factor of the receivers can be measured, but this is only a special case of the general statement made above.

NEW PRODUCTS

A welcome addition to the Collaro range of radio-gramophone units is the R.P. 49 rim-driven Single Player Unit. This can be obtained with magnetic or crystal pick-up, as also bakelite or balanced metal tone arm.

While the usual standard of Collaro equipment has been maintained, this rim-driven unit provides the answer for the manufacturer or other user who requires a cheaper type of unit than the well-known A.C. 47 direct rim-driven Collaro Unit.

The motor is powerful induction type suitable for A.C. supply of 100, 130, 200, 250 volts, and is fitted with cooling fan. Automatic stop and start is featured, and the turntable is 1 in. in diameter.

Indent orders can be placed through the New Zealand agents, who also have a supply of descriptive leaflets. Inquiries should be addressed to the Russell Import Co., P.O. Box 102, Wellington.

OUR GOSSIP COLUMN

MAYOR OF AUCKLAND TO TOUR GREAT BRITAIN

Mr. J. A. C. Allum, founder and head of the well-known firm Allum Electrical Co., Ltd., accompanied by his wife and daughter, is to leave in April for an extended tour of Great Britain. Seldom does Mr. Allum take time off either from business or municipal affairs, and the trip by sea will be a pleasurable relaxation. However, business contacts will be made with the innumerable principals of the company, and it is also safe to say that, as Mayor of Auckland, His Worship will indulge not a little in the study of municipal affairs whilst overseas.

* * *

Don Cooper has recently returned from a caravan holiday, with headquarters in the Waikanae district.

* * *

Norman Swann is back in Wellington after a long spell in Australia.

* * *

Chris Matthews, of National Electrical and Engineering Co., Ltd., spent his annual holidays in Sydney, during which time he visited the Ashfield works of Amalgamated Wireless Valve Co.

* * *

Mr. C. W. Rickard, director of C. & A. Odlin, Ltd., accompanied by his wife, left for Australia on 17th March on a well-deserved holiday. It is some years since Mr. Rickard saw his home town, Adelaide, so, after brief contacts at Sydney and Melbourne, there will be a pleasant reunion of relatives and friends at the delightful South Australian capital. Mr. and Mrs. Rickard plan to return to New Zealand on 17th May.

* * *

A 400 B.C. Hobby

Of all the interesting hobbies abounding in New Zealand, that practised by Mr. J. K. Scobie, Manager of the National Electrical and Engineering Co., Ltd.'s factory at Kaiwarra, is perhaps one of the most unique. It takes the form of the application of vitreous porcelain enamelling as a medium of expression—that is employing some of the methods used in the production of porcelain for electric ranges, etc., to create works of art, the result achieved being not unlike oil paintings, and yet quite different in the light and shade effects. We learned from Mr. Scobie that, while vitreous porcelain enamelling in metal goes back to the fourth or fifth centuries B.C., he believes that his own technique—the successful burning of several colours in one operation—resembles the process employed in the 15th century A.D.

Some of Mr. Scobie's work was exhibited recently in Wellington, where it drew high praise from a large number of people, many of whom came from overseas.

A representative from *Radio and Electronics* was privileged to enjoy a private viewing of many charming productions, among which were land and seascapes, and original designs featuring oriental expression, tropical fish, birds, etc.

We wish Mr. Scobie every success in the development of this hobby and hope that the knowledge of his achievements will become more widespread in the near future.

We extend our congratulations to Mr. J. H. Pricket, recently appointed general manager for S.T.C. in New Zealand.

In 1912, Mr. Pricket commenced his electrical engineering career with the Silvertown Company in England. During 1921, he went to South Africa, where he studied at the University College, Durban, Natal, and in 1923 he joined the South African Post and Telegraph Department. In 1925, Mr. Pricket became associated with Standard Telephones and Cables, Ltd., London, as an installation engineer, his duties taking him to South Africa, the Argentine, Chile, Uruguay, and the West Indies. In 1939, he went to Australia as resident engineer on the North Sydney telephone exchange (first exchange in Australia equipped with 2000-type system). On completion of this installation, he was appointed production superintendent at S.T.C.'s Sydney factory, and in 1944 came to New Zealand to take up duty as manager of S.T.C., Wellington.

* * *

Our congratulations go to Colin J. Peard, accountant to the head office of the National Electrical and Engineering Co., Ltd., whose wife presented him with a bonny daughter on 25th January this year.

* * *

It is with considerable interest that we learn that one of radio's most popular identities has decided to resume active interest in the trade. We refer to genial Miles Nelson, well known to all radio dealers and manufacturers. Miles, who during the war years suspended his activities in the radio field and became interested in other ventures, has decided to resume and expand his activities to a considerable degree.

He has formed the company of Miles Nelson, Ltd., organized to exploit Miles's already existing well-known agencies and a whole series of new ones as well. Miles has enlisted the services of Russ Denham and Brack Brackenridge, both well known to the trade throughout the Auckland province, and both having a wide and varied experience. Miles Nelson is imbued with the idea of service to the customer, and both Russ and Brack are determined to see that this is carried out—an excellent basis on which to build.

In advisory capacity as directors to the new company are George Wooller and Bill Blackwell, both well known in their respective spheres of the radio industry.

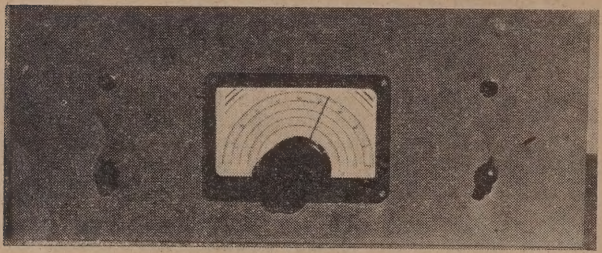
We extend to Miles a welcome back to the trade and all good wishes for success.

The PHILIPS Experimenter

An Advertisement of Philips Electrical Industries of New Zealand.

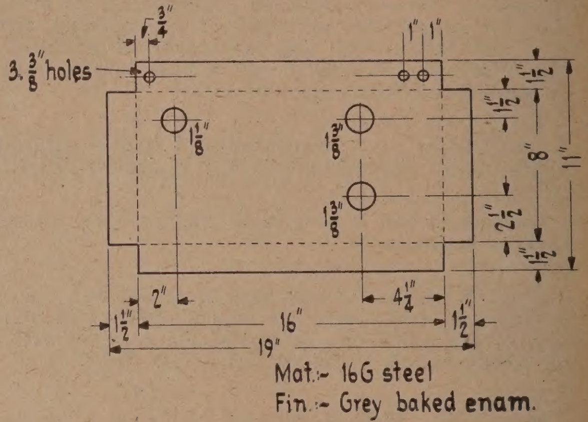
No. 17: A HIGH-STABILITY V.F.O. (PART 2)

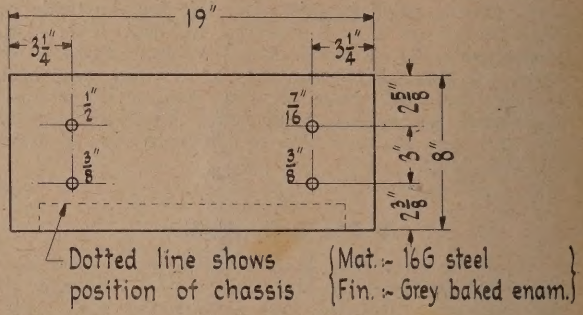
In the Experimenter No. 16, we gave the circuit and a technical description of the V.F.O. This part completes the practical and constructional side of the story. Working drawings for the chassis are given, and in addition several photographs, which will serve to make the verbal description clearer.

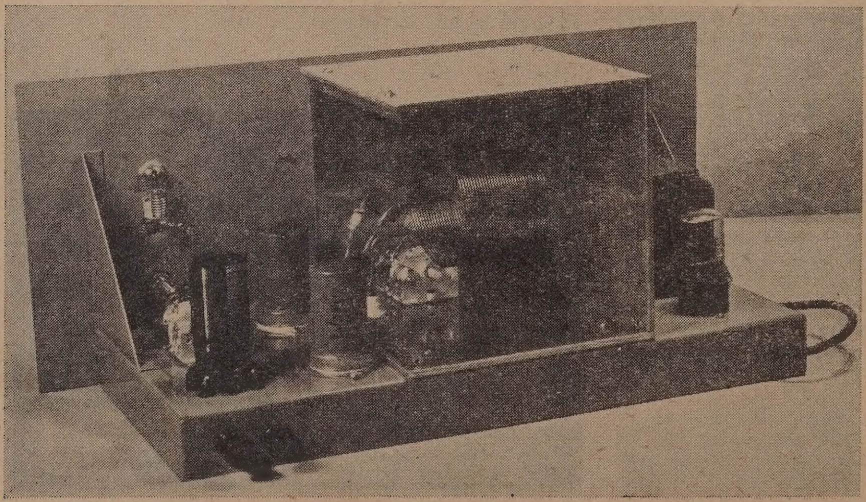


LAY-OUT OF THE CIRCUIT

This can be seen in the photograph at the bottom of this page. Approximately in the centre of the chassis is a large aluminium box, made of 3/16 in. aluminium sheet, and of inside dimensions 6 in. x 6 in. x 6 in. This box houses the oscillator tuning coil, L_1, which is a large affair, 3 in. in diameter. The use of a heavy aluminium box like this helps considerably in preventing slow frequency drift, due to temperature changes affecting the coil. Although the valves and power transformer do not generate very much heat, it is desirable to keep as much of it as possible away from the coil. Also, the use of a heavy box slows down very much the changes in room temperature, which would otherwise affect the coil directly. The box acts as a heat buffer, since if the room temperature rises or falls, the large mass of metal in the box has to change its temperature before that of the air **inside** the box can alter. In this way, the effects of rapid temperature changes are almost entirely excluded from the coil itself.







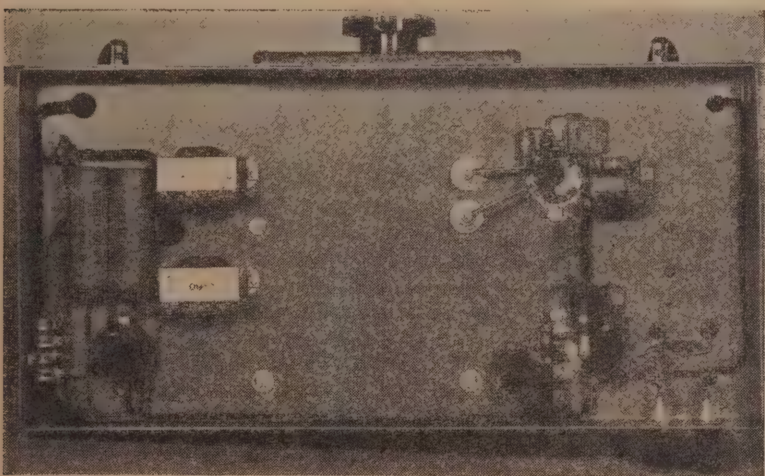
The box is held together by means of square brass rods at each corner and in the photo, where the back and one side of the box have been removed in order to show the coil, some of these can be seen quite clearly. The sides are attached [illegible] small machine screws, for which the brass rods are threaded; the holes in the sides of the box are not themselves threaded, as it is almost impossible to thread aluminium at all finely. The screw-holes are therefore large enough for the screws to pass through freely.

On the left of the coil box, looking from the back, are the two valves and the output tuned circuit, while the power transformer and rectifier are on the other side of the box. The valve nearest the front panel is the oscillator, while the front one in the photo is the doubler. The doubler plate coil is wound on a ribbed 1¼ in. diameter former, which is screwed directly to the chassis, since no coil-changing has to take place. Behind the coil, and beside the oscillator valve, can be seen the doubler tuning condenser.

The spaciol construction should be specially noted. This, again, is to allow as much air circulation as possible round the valves and power transformers, so that the heat developed by them can be carried away as quickly as possible.

CONSTRUCTION OF THE OSCILLATOR COIL

The proper construction of the oscillator coil is perhaps the most important single item in building the V.F.O., as the success of the whole thing depends on the mechanical and electrical stability of



the coil. Unfortunately, the method by which the coil is supported inside the box does not show properly in the photo, the appearance being rather as though the coil is floating in mid-air. The coil is constructed according to the so-called air-wound method, the only supports being four thin strips of celluloid. To wind the coil, a piece of 3 in. diameter coil former is obtained, and a saw-cut is made lengthwise in it. This enables the coil to be removed from the former after winding. Next, four narrow strips of celluloid (18-gauge sheet, ¼ in. wide) are fastened along the former, evenly spaced round it, at the ends of two diameters placed at right-angles. They are held in place by a turn or two of wire at each end of the former. When this is ready, a length of 20-gauge enamelled wire is wound off the reel; 24 feet are needed for the actual coil, but as we are going to double the wire and wind on two turns at once, to give the spacing for the finished coil, 48 feet altogether will be needed. This is stretched by a foot or so, doubled by clamping the two ends together in the vice, and is then ready for winding. The doubled end is passed under one of the celluloid strips on the former and round a couple of times so that it will not slip. Then 30 turns of the doubled wire are carefully wound on, as tightly as may be, and with care to see that all turns are touching all round. At the end, the wire is clamped under one of the strips, as at the beginning. Then, making sure that the other one can not shift, ONE of the finishing wires is let go and carefully removed without disturbing the spacing of the remaining one. This finishes the actual winding, and all that has to be done is the finishing. Four more ¼ in. strips of celluloid are made and each is fixed over the ones on the former, after having applied a liberal coating of celluloid cement or "Octopus" glue. When this is dry, it is now possible to remove the former by squeezing it inwards until the edges overlap and it can be withdrawn from the coil.

SUPPORTING THE COIL IN THE BOX

The supports for the coil are made from ⅛ in. perspex sheet, and are rectangular pieces, 2¾ in. x adjacent celluloid strips on the coil, so that they are at right-angles when the job is finished. It is as well to give the mounting strips extra support in the shape of lengths of perspex, 2¾ in. long and ⅛ in. square. Four of these are needed, and two are glued so as to make corner blocks at the joins of each mounting strip. With these added, the whole structure is extremely rigid, and will stand a surprising amount of force without the slightest deformation. The coil is fixed in the box with four machine screws, two to each mounting strip, and the coil is turned so that one strip attaches to the top and the other to the front of the box.

PLACEMENT OF TUNED CIRCUIT COMPONENTS

Since we are going to some trouble to heat-insulate the coil, it would seem wasteful not to place the rest of the tuned circuit components inside the box, too. In the original, this was done, including even the 100 $\mu\mu$f. grid coupling condenser. The photo shows how the main tuning condenser is mounted in relation to the coil and box. It is not in the centre of the front of the box, because the latter is not central with respect to the chassis, as has been mentioned before. The exact placement does not matter very much, of course, and as long as a good electrical lay-out is obtained, is not critical. For this reason we have not given exact details of the original, though, if the same chassis is used, a similar lay-out of the tuned circuit parts is advisable. At the left of the tuning condenser (in the photo) can be seen the two feed-through insulators which carry the only two leads out of the box. They can also be seen in the under-chassis view. The two leads referred to, of course, are those to the grid and cathode of the oscillator tube. To terminate the ends of the coil, two small solder-lugs were riveted to the horizontal supporting piece of perspex. This

brings the coil ends right above the main tuning condensers and allows the leads to be quite short. A third lug was also provided on the support, and this becomes the anchor point for the junction of the two 0.002 μf. condensers. The heavy bus from the feed-through insulator to this lug can be seen in the photo.

CIRCUIT VALUES

On the original circuit diagram, which appeared in the last issue of the Experimenter, the oscillator and doubler coils were designated simply as L_1 and L_2. The construction of L_1, the oscillator coil, has been given in detail, but it still remains to give the winding data on the doubler coil and to say a few words about the tuning condenser marked C on the circuit diagram.

L_2 consists of 44 turns of 20-gauge enamelled wire, close wound on the 1¼ in. ribbed former. The output coupling is by means of a twisted pair line, attached to a five-turn coupling coil, wound of the same wire as the plate coil, ⅛ in. from the lower end. In the underneath photo, the two Belling-Lee terminals for the output can be seen on the back of the chassis.

The main tuning condenser, C on the diagram, is shown as a variable condenser in parallel with a fixed one, no particular values being assigned. These values can be varied according to the exact range from the V.F.O. In our case, it was decided to make the fundamental range of 1.75 to 2 mc/sec. cover more than three-quarters of the available dial space. This is a nice compromise between bandspread and the ease with which the required band can be centred on the dial. The variable portion consisted of a 100 $\mu\mu$f. Polar midget condenser, with a 3-30 $\mu\mu$f. Philips trimmer in parallel with it. The fixed portion is a 100 $\mu\mu$f. silvered mica, with a plus or minus 2 per cent. tolerance. This arrangement enables the band to be set in the centre of the dial by means of the adjustment of the Philips trimmer, and it will be found that there is only about 15 degrees at each end of the dial that is outside the band 1.75-2.0 mc/sec.

POWER SUPPLY

The power supply was not shown on the circuit diagram in order to conserve space, as it is of quite ordinary design. The stability of the frequency of the V.F.O. with respect to supply voltage variations is so good that it was considered a waste of money to indulge in a regulated power supply. For this reason, the H.T. supply consists of an ordinary 280v.-a-side 60 ma. transformer, with a 6X5 or EZ35 rectifier, and a choke-input filter of two sections. The latter was chosen because a hum-free power supply is essential with a V.F.O. if the note is to remain clean after several stages of frequency multiplication have dealt with the signal. The load on the transformer is very light, as the figures in the last issue of the Experimenter show, so that there is only a slight rectifier voltage drop, and very little, too, in the smoothing circuit. With this arrangement, the note was as clean as the proverbial whistle. An on/off switch is provided on the front panel of the V.F.O., on the left-hand side, and above it is a panel lamp in its bezel, to show when the A.C. is on. On the right-hand side, above the doubler tuning control, is a second bezel. This houses a second panel lamp, or preferably a low-wattage torch bulb, which is connected to the R.F. output terminals by means of a twisted pair. This lamp acts as a tuning indicator for the doubler plate circuit, and shows when the latter is properly tuned. In some cases, according to how much driving power the next stage requires, the lamp may use up too much of the available output power. In this case it can be omitted, and the grid current of the next stage used as an indicator of correct tuning of the doubler plate circuit.

CONSTRUCTION

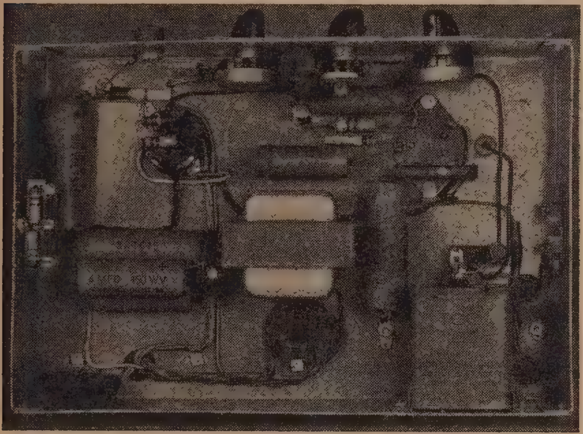
At this stage it should not be necessary to emphasize further that the success of the V.F.O. depends even more on the construction than on the circuit. The latter is not at all critical, either as to physical construction or operation, so that there is any amount of leeway for those who wish to use a different mechanical design. We ourselves have no objection to this, as the one represented here is really only illustrative of what can be done. As long as the necessary constructional principles are borne in mind, there is no reason why any variation on the original theme should not work equally well.

More about the Economy 10-Watt Amplifier

Last month we gave the circuit of an amplifier which represents what is probably the most economical way of attaining an output power of 10 watts, and which has independent bass and treble boost controls built in. This month we show photographs of this amplifier, and have a little more to say about it.

Construction

The construction of the amplifier is of the simplest, and is well illustrated by the accompanying photographs. The chassis has been made a little larger than was absolutely necessary so as not to crowd the parts—in particular, those of the feedback network. The valves, the power transformer, and the output transformer are mounted above the chassis, while the smoothing choke, the 4 μf. oil-filled condenser, and all the remaining components are mounted underneath. As can be seen, there is plenty of



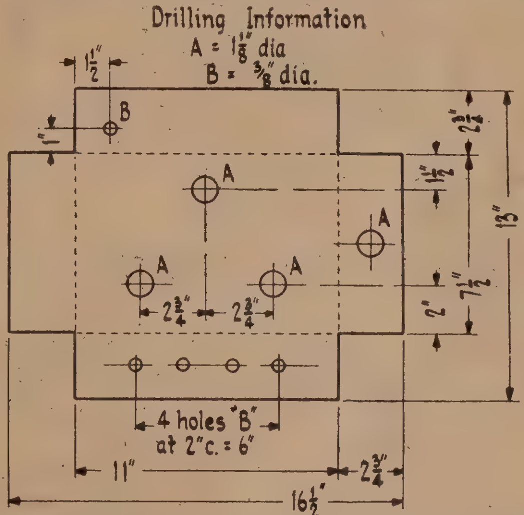
Underneath view of the amplifier. In the bottom right-hand corner is the 4 µf. blocking condenser in the feedback line, and in the centre is the smoothing choke. On the left is the working drawing for the chassis.

room for everything without crowding, and the lay-out is consequently very straightforward. In the underneath view, the 807 socket is on the left, with the 6J7 on the right. In the centre, towards the back, is the rectifier, and on the back of the chassis can be seen the 4 μf. condenser. The various electrolytic condensers can be seen on each side of the smoothing choke, and the number of small resistors and condensers is so slight that it should be possible to identify them from the photograph.

An important point is the manner in which the controls are arranged. At the left in the photograph can be seen the input socket, which is an ordinary single-contact microphone connector; the control nearest to it is the volume control, the middle one is the treble boost, while the right-hand one is the bass boost control. It should be noted that the feedback loop, which contains the boost controls, is taken round the right-hand side of the chassis, behind the 807 socket, and along the front of the chassis to the controls, and thence to the cathode of the 6J7. This placement ensures that the feedback loop does not approach too closely to the 807 grid circuit or to the 6J7 grid circuit. The latter is the danger spot, for if there should be appreciable capacity coupling between the feedback loop and the grid of the first valve, the feedback caused thereby will be positive—not negative—and could result in oscillation, most likely at some super-audible frequency.

Some Further Points about the Circuit

The hum level in this amplifier is well down, owing to the use of an indirectly heated output valve, but some users, who may have a speaker system with a particularly good bass response, might feel that it is too great



for comfort. If this is the case, two simple modifications can be made to the circuit. The first is to add extra smoothing for the plate supply to the 6J7. Since this valve takes only a litle more than one milliamp of cathode current, smoothing is not hard to apply, and consists simply of a 100k. resistor and an 8 μf. condenser, connected as in Fig. 1.

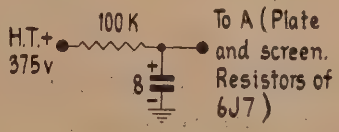
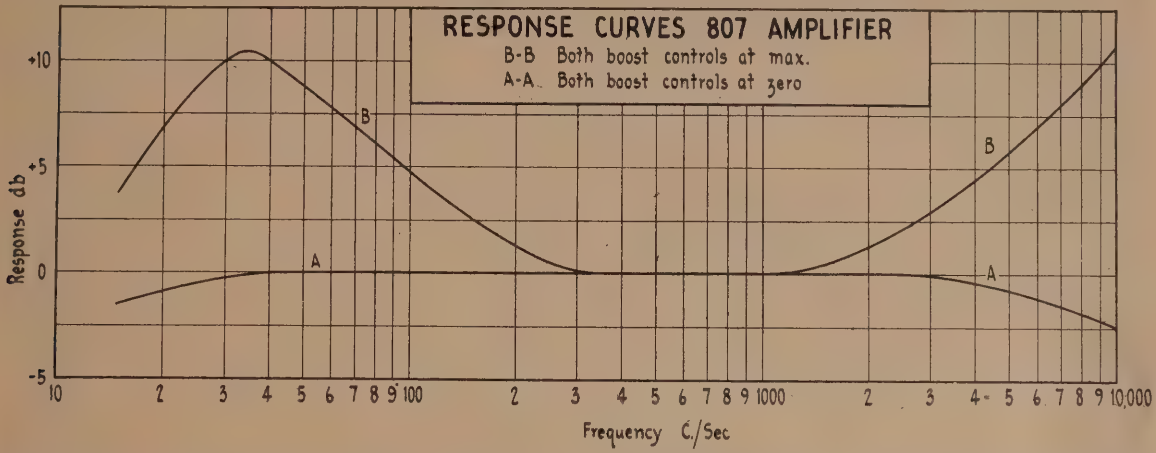


Fig. 1

The second modification, which is shown in Fig. 2, is necessary only if the speaker has appreciable response at 50 c/sec. Its purpose is to remove the last trace of heater-cathode hum arising in the 6J7. In this circuit the latter does not have its cathode bypassed by a high-capacity electrolytic condenser, and so is more susceptible to heater-cathode hum. The dodge used to get over this is that of cancelling out the hum that exists by introducing some out-of-phase hum into the amplifier, at a point where the amplification is not very great, so that

the adjustment of the cancellation is not critical. The heater circuit is changed to that of Fig. 2. Here, the winding is centre-tapped by means of two fixed resistors of 50 ohms each. Then the heater of the 6J7 is bridged by a 100-ohm potentiometer, and the screen condenser is returned to the moving arm of this, instead of directly to earth. This scheme works as follows. The fixed resistors establish a reference point on the filament circuit which is at earth potential. This means that there must be some point on the potentiometer which is also at earth potential as far as heater voltage is concerned, and that on each side of this point the 50 c/sec. voltage is in phase opposition to that on the other side. Thus, on the assumption that the hum arising in the heater-cathode circuit of the 6J7 is in phase with one or other of these voltages, it must be possible to introduce an out-of-phase voltage from the potentiometer which will oppose the amplified hum voltage in the output of the amplifier, thereby cancelling it out. By lifting the earthy end of the screen bypass condenser from the chassis and returning it instead to the tap on the potentiometer, we have a means of injecting the desired voltage into the amplifier in a non-critical manner. The adjustment is simply one of turning the potentiometer until minimum hum is heard in the output. While this is being done,, the volume control should be turned fully *off*, because the heater-cathode hum that is being eliminated by this means bears no relation to any slight hum that may appear when the volume is turned well up, and should this kind of hum be present, too, it will quite mask the effect of the potentiometer adjustment.

The scheme of Fig. 2 is really a refinement, to be carried out only in cases where the speaker has extremely good low-frequency response. In other cases it is not worth the trouble entailed, because the hum from this cause is so slight that it will not be heard in any case.



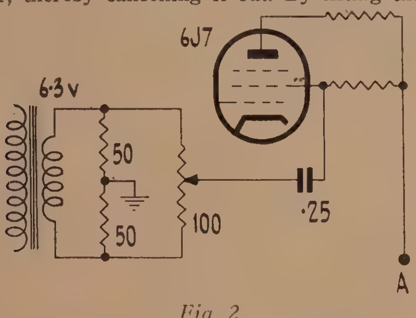


Fig. 2

Showing an effective method of hum-reduction. This does not entail a separate heater winding for the 6J7, the 807 being fed from the same winding.

Measurements showed that after both these precautions had been taken, the hum measured at the voice-coil winding of the speaker was less than 0.02 volts. This represents a hum level 54 db. below maximum output—a figure almost as good as the stringent requirements for broadcast equipment.

It is also a worth-while precaution against undesired oscillation to earth one side of the voice-coil winding of the output transformer.

Response Curves

The accompanying diagram shows response curves for the amplifier under various conditions of the boost controls. The flat portion in the centre of the range is quite unaffected by the operation of the controls, as are the portions at the low and high ends, when the opposite control is operated. The figure can therefore be taken as four separate response curves showing the effects with either control at maximum, both at minimum, and both at maximum. These curves were taken on a resistive load.

Input Voltage

This amplifier has rather less gain than the average owing to the high degree of negative feedback. It requires a signal of approximately 2 volts R.M.S. to load the amplifier to full output. This is adequate for any radio tuner, but might not be quite enough for some gramophone pick-ups, and if it is found that more gain is required for the pick-up, a low-gain pre-amplifier stage will have to be used. In the case of the modern high-fidelity lightweight pick-ups, this does not matter at all, since these require a tone-compensating pre-amplifier whatever amplifier they are used with. A suitable unit employing a single 6SN7 was featured in the March, 1947, issue of this journal, and with low-level pick-ups this will give much more than the necessary 2v. output.

S.O.S. RAINBOW TUNER

The above is a photo of the S.O.S. Rainbow dial reduced to one-quarter size, its overall dimensions being 12" x 6½". The basic colour of dark blue is surmounted with five rainbow colours, with a different colour to distinguish each band, and all the figures, lettering, and divisions are photo-etched into the glass in gold, giving the dial a very attractive appearance. The band colours are: Broadcast, red; 25-31 metres, yellow; 16-20 metres, green; 40 to 49 metres, blue; and 80 metres, violet. These translucent colours are indicated in the false Magic Eye on the left when the wave-change switch is rotated. On the right, provision is made for a dual-sensitivity Eye. In addition, to facilitate logging of stations, a scale of 0 to 100 is provided.

PRICE OF TUNER, INCLUDING EF41 and ECH41 Valves, but less EM34 Magic Eye Valve	*£14-15-0 d.*
Complete Kit for 7-Valve, including Speaker	*£27-10-0 d.*
Complete Kit for 9-Valve, less Speaker and O.P.T.	*£28-10-0 d.*
7-Valve Cadmium-plated Chassis	*15-0 d.*
9-Valve Cadmium-plated Chassis	*17-6 d.*
Table Cabinets available	*£5-0-0 d.*

Obtainable Only From

S.O.S. RADIO Ltd.

283 Queen Street Auckland

S.O.S. RADIO LTD.,
283 Queen St., Auckland

Please send me full information on the Rainbow Tuner.

NAME..

ADDRESS..

TOWN..

The "Junior" Communications Receiver

PART 3 Coils for the Receiver

tion of the carrier) from being heard in the output.

Sets which use plug-in coils usually mean a great deal of labour in winding the coils, especially where there are a number of wave-ranges and where each range requires three or even more coils. This need not deter the intending builder of this set, however, since there are only eight coils altogether, and, because they are wound on ribbed formers, 1¼ in. in diameter, they are much easier to wind than are the small coils needed for a band-switching receiver. All are wound with wire that is large enough to be easy to handle, and there are no tracking troubles to worry about, since the first detector and oscillator are separately tuned. In fact, it does not matter at all if the coils are not exactly to specifications, since the best performance is always assured because of the separate tuning. The worst that can happen is for small gaps to occur in the coverage, between coils, and this can easily be guarded against when the oscillator coils are being wound. The table below gives the style of winding and the number of turns for all eight coils. It is not even important to stick to the pin-numbering suggested, as long as the connections are made to the pins in the coils themselves. Just the same, the coils should be made as closely to our specifications as possible, as there will then be no doubt about full coverage if the builder has no means of accurately checking this for himself.

Coil-winding Data

Note.—all coils are wound on 1¼ in. ribbed formers. Four-pin ones are used for the aerial coils and five-pin ones for the oscillator coils, so that it is easy to identify them and so that they will not be plugged into the wrong sockets.

AERIAL COILS

Band 1:

Grid Winding: 48 turns of 20-gauge enamelled wire, close-wound.

Aerial Winding: 20 turns of 30-gauge enamelled wire, close-wound over the few lowest turns of the grid winding.

Band 2:

Grid Winding: 18 turns of 20-gauge enamelled wire, double-spaced.

Aerial Winding: 9 turns of 30-gauge wire, in three groups of 3 turns each, between the three lowest turns of the grid winding.

Band 3:

Grid Winding: 9 turns of 20-gauge enamelled wire, spaced to occupy ⅞ in. of winding space.

Aerial Winding: 4 turns of 30-gauge enamelled wire, inter-wound between the lower turns of the grid winding.

Band 4:

Grid Winding: 5 turns of 20-gauge enamelled wire, spaced to occupy ⅝ in. of winding space.

Aerial Winding: 3 turns of 20-gauge enamelled wire, close-wound, ⅛ in. below the bottom turn of the grid winding.

Note.—When wound, all coils should be cemented in place with coil cement or celluloid cement.

OSCILLATOR COILS

Band 1:

26 turns of 20-gauge enamelled wire, double-spaced, and tapped at 13 turns.

Band 2:

12 turns of 20-gauge enamelled wire, double-spaced, and tapped at 6 turns.

Band 3:

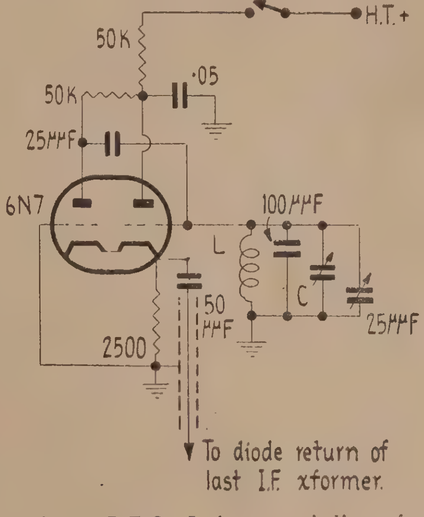
6 turns of 20-gauge enamelled wire, spaced to occupy ½ in., and tapped at 3 turns.

Band 4:

3 turns of 20-gauge enamelled wire, spaced to occupy ½ in., and tapped at 1½ turns.

Noise-limiter

The noise-limiter circuit used in this set is one that has appeared before in these pages. It is known as the parallel or shunt noise-limiter circuit, because the limiter diode is in parallel with the detector diode load resistor. The circuit operates as follows. When the limiter on/off switch is in the "On" position, it is closed, thereby applying a negative bias from the A.V.C. line to the plate of the limiter diode. The cathode of this diode is connected to the junction of R_{21} and R_{22}. These resistors are each 500k., and together make up the detector load resistor, not counting the filter resistor R_{20}, which does not count as far as the working of the limiter is concerned. Thus, one-half of the available audio voltage



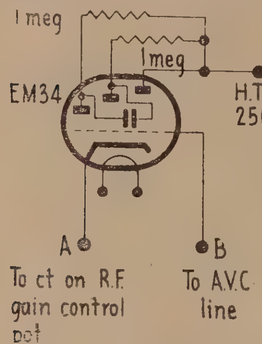
Circuit of the B.F.O. L is one winding of a 175 kc/sec. I.F. transformer, and C represents BOTH trimmers of the transformer wired in parallel. The shielded output lead goes to the junction of R_{19} and R_{20}.

from the detector is applied to the limiter cathode. Since the plate is held negative with respect to the cathode, the limiter has no effect on the audio signal. However, when a noise occurs that is much greater in amplitude than the 100 per cent modulated carrier, this drives the cathode sufficiently negative to overcome the negative bias on the diode plate, and the limiter conducts. When this happens, the diode acts as a short-circuit across the detector load resistor, thereby preventing the noise (or at least that part of it which is greater in amplitude than an audio signal representing 100 per cent modula-

Thus, the limiter does not act as a noise eliminator, for it can never do that, but simply limits the noise to the maximum possible audio level from the signal itself, and prevents it from being any louder than this. The circuit is self-adjusting, and does not need to be set by means of a manual control on the front panel of the set.

Magic Eye and B.F.O.

These have not been shown on the main circuit diagram, as some constructors may not wish to incorporate them. Their circuits are therefore shown separately, with the points of connection to the main circuit shown on them. The connection of the magic eye to the set is a trifle unusual, because of the unusual detector circuit,



Circuit of the EM34 tuning indicator. The cathode is not earthed, but is connected to the moving arm of R_{25} in order to prevent the manual gain control from affecting the reading. Neither the lead from A nor that from B needs to be shielded.

which has already been explained. Normally, the cathode of the eye tube is taken to earth, and the grid either to the A.V.C. line or to the high-potential end of the detector diode load. Here, the connection of the grid is as usual, being taken to the A.V.C. line, but the cathode is taken not to earth, but to the moving arm of the manual gain control potentiometer. The reason for this is that were the cathode connected to earth, the grid of the eye tube would have the control bias fed to it in exactly the same way as the controlled valves, with the result that the eye would not indicate, if the manual control were wound down at all. With the cathode connected to the source of bias, as well as the grid, the manual bias control has no effect at all on the operation of the eye, which operates on the signal voltage developed by the detector diode, whether or not the manual control is in use.

The B.F.O. circuit is one which has been used in these pages several times before, and uses a double triode in a cathode-coupled oscillator circuit. The output is taken from the cathode of the oscillator valve, and goes through a shielded cable to the low-potential end of the last I.F. transformer. The B.F.O. must clearly work on 100 kc/sec., and in order to avoid having a special oscillator coil made, a single winding from a 175 kc/sec. I.F. transformer was used, together with the can and trimmer base, both of the trimmers being used. They are wired in parallel, and in addition a further 100 $\mu\mu$f. fixed condenser is placed in parallel with the winding. The B.F.O. pitch control is mounted on the front panel, and is a 25 $\mu\mu$f. max. capacity variable. It can be seen in the photograph published last month, at the left of the magic eye tube, in front of the B.F.O. coil can.

The most useful feature of this B.F.O. circuit is that it does not need a tickler winding or a tap on the tuned circuit, being what is known as a two-terminal oscillator. For this reason, if a special 100 kc/sec. oscillator coil is not available, it is a simple matter to buy an ordinary 175 kc/sec. I.F. transformer and to use it in this circuit, since all the modification needed is to cut through the former so as to remove the lower winding, which is not needed, and then to wire both trimmers in parallel across the remaining winding. The method of output coupling shown is a good one in that it makes it difficult to get too much B.F.O. voltage injected into the detector circuit—which is a bad fault if it occurs, as it reduces the sensitivity of the set by operating the A.V.C. too strongly. With the circuit shown, no trouble of this sort will be experienced.

Construction

The type and detail of the construction is readily seen from the two photographs which appeared in the last issue and in the present instalment. The coil in the centre of the chassis is the oscillator coil, the other, of course, being the 1st detector coil. Behind this is the 6J6 mixer. Then, behind this again, is the 1st 1,600 kc/sec. I.F. transformer, with the 6BA6 I.F. stage in the corner of the chassis. The circuit then progresses along the back of the chassis, exactly according to the circuit. At the other back corner can be seen the 6H6, with the first and second audio stages down the other side of the chassis. Then, in line with these are the 6N7 B.F.O. valve and the B.F.O. coil. The second oscillator coil can be seen directly in front of the ECH35 (when looking from the front of the set). The valve hole to be seen on the chassis diagram beside the 6V6 socket hole is the one for the rectifier.

There is an error on the chassis diagram, which though not a serious one would be a little annoying in practice. The hole for the 6J5 oscillator has been shown as $\frac{5}{8}$ in. in diameter, instead of $1\frac{1}{8}$ in. It is the one marked "B" immediately to the left of the hole for the oscillator coil socket—the one at the front in the centre of the chassis. The two small holes on the left-hand side of the chassis are for the aerial and earth terminals, while the large one on the right-hand side of the chassis is for the speaker plug and is next to the 6V6 socket hole. If it is not intended to mount the set in a rack, the front panel need not extend so far on either side of the chassis, and two inches or so can be cut off each side if desired. Under the chassis, as can be seen from the photograph, there is a box placed round the circuit of the ECH35. This was included in the original model in case trouble was experienced from harmonics of the second oscillator, but later experience has shown that it is not necessary, and that if the circuit values throughout are adhered to, there will be no trouble from this source.

In the photograph of the underneath of the set, the top of this shield box has been left off so that all the wiring could be seen. Another feature of the construction which should on no account be omitted is the small cross-socket shield for the 6BA6. This can be seen in the bottom left-hand corner of the photograph. It is arranged so that the grid pin, No. 1, is shielded from all the others. This is simply done by making two right-angle bends in the shield partition, as shown, the short piece being only $\frac{1}{8}$ in. long.

The shield is then positioned in such a way that the grid pin of the 6BA6 is on one side of the shield, in the corner formed by the right-angle bend, and the remaining pins of the socket are all on the other side of the shield. The partition is soldered to the central pin-shield on the socket and is bolted to the chassis by means of two flanges, made so as to be parallel with the chassis.

Mounting the Tuning Condensers

As can be seen from the photographs, the main tuning condensers, i.e., the first detector condensers and the two variables in the oscillator circuit, are all of the midget

silver-plated type in which the only insulating materials are the two small ceramic posts which support the stator. These condensers have tapped mounting holes underneath, on the frame, and, because of their small height, cannot be mounted directly on the chassis, as if so, the shafts would not be high enough to reach the holes in the panels through which the condensers are to be operated. For this reason, three small mounting brackets are made from 18-gauge aluminium. These brackets are simply small platforms, made to the external dimensions of the condensers, and of the required height to bring the shafts opposite the holes in the front panel. The platforms are of simple U section, and are screwed to the chassis with four nuts and bolts, two in each of the mounting flanges. Apart from these, no mechanical work is necessary once the main chassis has been made.

Lay-out of the Wiring

There is very little that can be said about this, as the circuit is followed very closely by the physical lay-out of the valves and the I.F. transformers. The usual precautions of making the leads carrying R.F. as short and direct as possible are, of course, necessary in this set, as in all others. It will probably have been noticed by readers that in all our chassis designs we do not show large holes underneath the I.F. transformers. This is often done by manufacturers, as large holes can be punched out in a press more cheaply than three or four small holes can be drilled. In the case of the amateur constructor, however, there are two advantages in drilling small holes under the I.F. transformers and taking the leads through them, one hole to each lead. For those who build their own chassis, this is easier to do, and there are electrical advantages as well, in that the I.F. transformers are much better shielded than if there is a large hole directly underneath them. The "hot" leads can then be terminated on lugs mounted directly under the transformers, and this gives the right number of much-needed anchor points for things such as A.V.C. filter resistors and bypass condensers and for plate de-coupling resistors and condensers—components which are all too often omitted altogether by commercial designers on the score of economy. As can be seen from the photograph, all resistors and condensers have been laid at right-angles to, or parallel with, the sides of the chassis, thereby giving a very neat appearance, which is not to be despised, because, unless long leads are made where they should be short, a neat job can almost alway be relied upon to perform better than one in which the resistors and condensers appear to have been thrown in from a great distance and fixed where they landed!

On the other hand, it is a waste of time and ingenuity to try and keep short leads which carry only D.C. and which have been de-coupled from signal voltages of all kinds. In the under-chassis view of the set, a row of long leads can be seen going from front to back on the chassis. These are cases in point, and serve to illustrate this point. The leads in question go to the A.V.C. long-time-constant switch, the noise-limiter on/off switch, and the manual gain control. Now, all these carry D.C. only—that is, assuming that the de-coupling resistors and condensers have been mounted in their correct places. For instance, take S_3, the noise-limiter on/off switch. This requires two leads to be taken from the back of the chassis, where the A.V.C. rectifier (the final detector) is to be found, right across the chassis to the switch, which is mounted on the front panel. Now, as long as the R.F. filter R_{19}, C_{22}, is placed where it ought to be—namely, as close as possible to the V_5 socket, it does not matter by how long or indirect a route the leads to the switch travel. This is because there is nothing but D.C. on the A.V.C. line, the R.F. having been removed by the components mentioned. Because of this, the long lead to the switch can neither pick up nor radiate R.F. voltages, and can therefore not cause instability. Now, let us see what could happen if the R.F. filter were not mounted close to the 6H6, but that a long lead was taken from R_{20} to R_{19}. In this case, one would find the filter components at the end of a long wire which carries R.F., and which can radiate to other parts of the circuit, and which can also pick up R.F. radiated from elsewhere, with the net result that feedback and instability occur. Electrically, the circuit would still be the same as drawn, in that no mistaken connections have been made, but would not be satisfactorily constructed.

In general, our circuits are drawn so that leads which need to be short are drawn so on the diagram, but this is not always possible, and a certain amount of distortion has to be wielded by the constructor himself.

These warnings should not be taken to mean that only an expert can build up this or similar sets successfully. Far from it. The present set will be found exceedingly easy to get going and to possess an absolute minimum of potential "bugs." Readers will no doubt remember the "Radel DX Broadcast 12." This was a receiver with two R.F. stages and two I.F. stages—in fact, one with almost unlimited possibilities for instability trouble, and in spite of the fact that amateur constructors are known to have built quite a number of these sets, we have not heard of a single case of difficulty of this sort. It was with some trepidation that we let that particular set loose, because it was realised that it was really a tough job for amateurs to tackle, but experience has shown that, given a sufficient lead in the way of mechanical and electrical design, amateurs can successfully accomplish potentially very difficult jobs. There is thus not the slightest need for anyone to doubt his capability of doing well with the present circuit.

Alignment

The alignment of a double superhet. like this one is no more difficult than that of an ordinary dual-wave receiver and a good deal easier than many. The first step is to set the 100 kc/sec. I.F. transformers on frequency in the usual way, starting with the winding nearest the diode detector and working backwards to the primary of T_5. When these have been peaked up, the signal generator is set to 1600 kc/sec. and fed in to the grid of the second mixer, V_3, through a blocking condenser. The trimmer of the second oscillator is then turned until the 1600 kc/sec. signal is heard and is properly tuned in. No further readjustment of this condenser is then needed. The signal generator is then kept at 1600 kc/sec., and the trimmers of T_3 and T_2 are aligned for maximum output. This is really all the alignment that has to be done. Since the first detector and oscillator are separately tuned, there is no question of tracking them. All that has to be done is to ensure that, with both the oscillator condensers at maximum capacity, the coil, T_1, is of the right inductance to peak up a signal with C_2 very nearly at maximum capacity. If the coil windings are made according to the accompanying instructions, there will be no difficulty about this at all.

Operating the Set

We have been to some trouble to impress on readers that this set has exceptionally good signal-to-noise ratio. Now, some people seem to think that a set with such characteristics can have all gain controls set at maximum,

(Concluded on page 45.)

THE SECOND PRIZE-WINNING DESIGN IN THE *RADIO and ELECTRONICS* PORTABLE COMPETITION

This receiver is the one designed by Mr. M. E. Pattinson, of Masterton, and which won the second prize in our Portable Competition. It is an excellent set for districts, such as Mr. Pattinson's own, where "local" stations do not really exist, making conditions for a portable set rather difficult.

Objects of the Design

In designing this receiver, the following points were considered the most important ones to strive for, and accordingly have their effect on the finished job.

(1) Sensitivity:

This must be high, so as to make the set as effective as possible under country conditions, where there are no local transmitting stations and where signal strengths are consequently low.

(2) Battery Consumption:

This must be as low as possible, consistent with (1). Low battery drain is very desirable in any portable set at all, and is realized by the use of the low-consumption miniatures and by deciding upon a relatively low audio power output.

(3) Audio Quality:

The audio quality was desired to be as good as possible, consistent with both (1) and (2). The use of negative feedback is an important point in the design, which is not often found in portable receivers.

(4) Size:

As no importance, in this particular case, was placed on achieving an ultra-compact mechanical job, it was decided that the only limitation would be that the set must not be larger than the average commercial portable (not counting the battery-A.C. types, which are somewhat larger).

Circuit Details

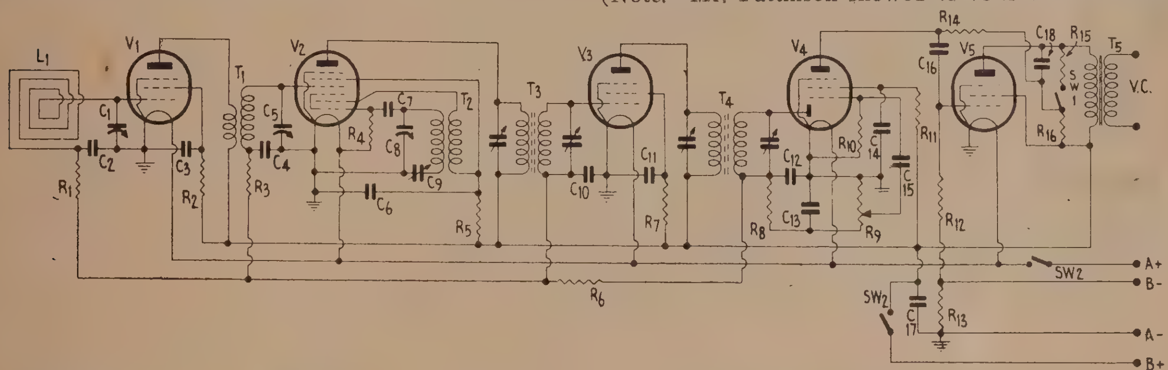
The salient features of the circuit design are as follows:—

(1) R.F. Amplifier:

A fully-tuned R.F. amplifier stage is used in order to get the most from the set in the way of sensitivity. (Note.—Mr. Pattinson showed 45 volts on the screen and plate of the R.F. stage, obtained from the 90v. B battery through a dropping resistor. The judges were unanimous in agreeing that the loss of gain resulting from this would too greatly offset the slight possible saving in H.T. current. As a result, the circuit has been amended to put the full 90 volts on the plate, the dropping resistor being used to reduce the screen voltage to 67.5 volts.)

(2) Mixer:

This stage uses a new valve, the DK40. This valve is of the now well-known Rimlock construction, and has more conversion gain than the conventional 1R5 or DK91. It has a different electrode arrangement, which enables a conventional circuit to be used. A dropping resistor is used to give the maximum rated oscillator anode voltage of 67.5.



R_1, R_3, 100k.
R_2,
R_4, 35k.
R_5, 7.5k.
R_6, R_{11}, 3.0 meg.
R_7, 75k.
R_8, 50k.
R_9, 1 meg. pot.
R_{10}, 10 meg.
R_{12}, 2 meg.
R_{13}, 270 ohms.
R_{14}, 750k.
R_{15}, 1 meg.
R_{16}, 175k.
L_1, loop aerial.
T_1, R.F. coil.
T_2, Osc. coil.
T_3, T_4, I.F. transformers, 455 kc/sec.
T_5, Output transformer, 22,500 ohms to voice-coil.
C_1, C_5, C_8, Midget gang condenser (Plessey).
C_2, C_4, C_{14}, 0.05 μf.
C_3, C_6, C_{10}, C_{11}, 0.02 μf.
C_7, C_{12}, C_{13}, 100 $\mu\mu$f.
C_9, 600 $\mu\mu$f. padder. Sw_{21}
C_{15}, 0.002 μf.
C_{16}, 0.001 μf.
C_{17}, 0.1 μf.
C_{18}, 50 $\mu\mu$f.
V_1, V_3, DF91.
V_2, DK40.
V_4, DAF91.
V_5, DL41.
Sw_1, D.P.D.T. On/Off.
B Battery, two type 482 (Eveready).
A Battery, one type 745 (Eveready).
(Note.—All coils specified by Mr. Pattinson are by Inductance Specialists.)

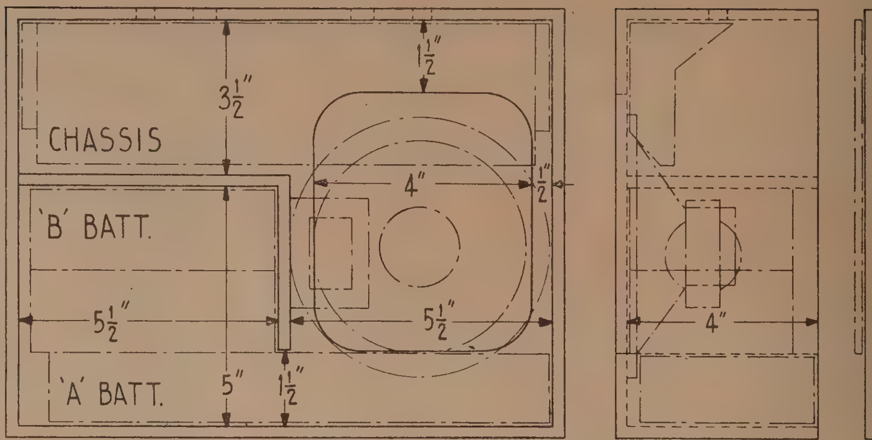
(3) I.F. Amplifier:

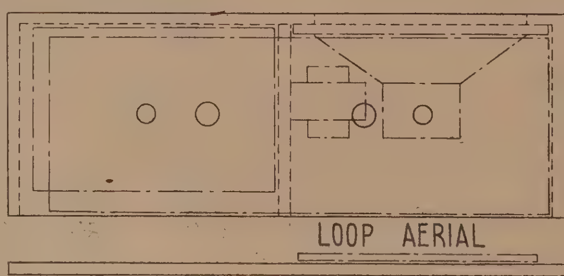
This is conventional except in so far as full-sized iron-cored transformers are used, so that maximum stage gain can be attained. In this stage, too, the screen is run at 45 volts so as to reduce the plate current and economize on B consumption.

(4) Output Stage:

The output valve is a DL41. This is also a new type, being of the Rimlock construction like the DK40. It has been slightly over-biased to reduce the plate current when the batteries are fresh, but the bias resistor has also been chosen so that when the batteries are run down, the bias is, if anything, a little less than optimum. By this means, the best performance throughout the life of the battery is assured.

The switch, Sw_1, is included so that the negative feedback can be removed from the output stage, either when the batteries are on the way down, or when more over-all gain is wanted for weak-signal reception.





Top right: Front elevation.
Top left: Side elevation.
Below: Plan view.

We're Here to

with a Nation-W

AUCKLAND: 409 Queen Street
G.P.O. Box 2268 Phone 40-225

WELLINGTON FACTORY:
Wakefield Street, C.3. Phone 56-604

WELLINGTO
Nimmo'
Cnr. Willis
C.P.O. Box 16

- RADIOPLAYERS
- VALVES
- SOUND EQUIPMENT
- FLUORESCENT
- LAMPS
- SPECIAL TYPE LAMPS
- TRANSMITTING

BACKING every Philips product is the Philips Service Organization.

Whatever the product . . . Radioplayers, Valves, Lighting, Sound Reproduction, X-Ray Equipment . . . you are assured of comprehensive assistance for any installation or servicing problem.

Bulletins, prepared regularly, keep you up to date on new developments and, for the expert advice of technician specialists, you have only

PHILIPS ELECTRICAL INDUS

MAKERS OF THE F

The "Radio and Electronics" Abstract Service

AUDIO EQUIPMENT AND DESIGN:

Low distortion cross-over network. Of special interest to users of loudspeakers capable of 30-cycle performance. Audio cross-over network, for woofer-tweeter speakers, uses low-pass filter between output valve and low-frequency output transformer to reduce distortion caused by non-linearity of transformer inductance.—**Electronics (U.S.A.), November, 1948, p. 98.**

Recording and reproduction of sound. Discussion of R-C tone control systems.—**Radio News (U.S.A.), October, 1948, p. 56.**

Reproduction of micro-groove recordings. Details of new Columbia L.P. records, turntable, and other equipment required.
—**Radio News (U.S.A.), October, 1948, p. 40.**

ANTENNAE AND TRANSMISSION LINES:

F-M and television receiving antennae. Reference sheet covering six types, giving approximate terminal impedance, radiation pattern details, and gain over dipole. Recommended feed lines, application, and remarks.
—**Electronics (U.S.A.), November, 1948, p. 118.**

CIRCUITS AND CIRCUIT ELEMENTS:

Composite amplitude and phase modulation. New system produces substantially single-sideband with carrier. Band width is approximately one-half that of double sideband method of modulation. The maximum modulation is 81.5 per cent. to give equal of 100 per cent. by double sideband method. Signal can be demodulated by receivers using linear diode detectors. Signal to one modulator is shifted 90 degrees, and this, with 90 degrees phase difference between sidebands from p.m. and a.m. cancels one set of sidebands.
—**Electronics (U.S.A.), November, 1948, p. 86.**

Power valve protective circuit. Simple circuit whereby usual disadvantage of relay (i.e., relay operates during adjustment of the valve load, or when transients are caused by switching in an associated part of the circuit) is overcome. By use of a diode in relay circuit and by suitably arranging resistors in cathode and grid circuits of power valve, grid and anode currents rise together.
—**Electronic Engineering (Eng.), November, 1948, p. 353.**

Grid-controlled vacuum rectifier. Brief description of circuit using 6SA7 valve (or two 1625s or 6L6s) for combined rectification and control. With 6SA7 valve and 325-0-325v. transformer, voltage variation from 140-382v. is obtainable.
—**Electronic Engineering (Eng.), December, 1948, p. 383.**

Power supply output voltage control. Circuit and construction of a unit for use with standard power supply. Uses series valve, grid-bias controlled, to give output voltage control. Suitable valves are 829-B, 6SA7, or 6L6.
—**Radio News (U.S.A.), October, 1948, p. 66.**

Wide-band amplifiers. Complete analysis of design of high-frequency, wide-band amplifiers, stagger-tuned. Tables of design data.—**Radio News (U.S.A.), October, 1948, p. 58.**

S-meters. Various circuits incorporating an S-meter in existing communications receivers.
—**Radio News (U.S.A.), October, 1948, p. 48.**

Versatile tone control. Circuit for bass and treble control. Bass and treble frequencies may be boosted or suppressed, each independently and in small steps. Selective frequency boost, treble boost, treble attenuation, bass boost, and bass attenuation obtained by employing suitable R-C networks. Any desired cross-over frequency obtained by choice of suitable resistance and capacitance value for networks. One hundred and twenty-one different response curve combinations possible for speech or music. Gain at 500-cycle cross-over is automatically held constant by use of cathode-followers. Choice of valves discussed.
—**Electronics (U.S.A.), December, 1948, p. 81.**

Precision interval timer. Electronic timer which is not subject to inaccurate operation due to ageing of valves, valve replacements, and other usual causes. Principle of operation based upon discharge of a capacitor, in R-C combination, through a voltage source of reversed polarity. Possible intervals, 0.01 to 100 seconds, repetitive to 0.75 per cent. accuracy. Circuit and construction.—**Electronics (U.S.A.), December, 1948, p. 88.**

MEASUREMENTS AND TEST GEAR:

Simple modulation meter. Circuit of a simple unit using 6H6 valves in fullwave bridge rectifier circuit; 0-500 microammeter used as indicator. Details of a calibrating device.
—**Electronic Engineering (Eng.), December, 1948, p. 399.**

Analysis of bridge-type valve voltmeters. Analysis of four types and comparison drawn between these in respect of sensitivity and high-frequency stability.
—**Wireless Engineer (Eng.), December, 1948, p. 377.**

Carrier-frequency voltmeter. Voltmeter for measuring strength of signals over power lines, telephone lines, and cables in region between 20-500 k/c. Instrument is basically a fixed gain, double-superheterodyne receiver. Microammeter in final detector circuit calibrated in db. Circuit details and construction.
—**Electronics (U.S.A.), December, 1948, p. 104.**

Hum reduction. Investigation of sources of hum. Circuit design data for reducing hum from alternating magnetic fields, electrical leakage, and other sources.
—**Electronics (U.S.A.), December, 1948, p. 112.**

RECEPTION AND RECEIVERS:

Build your own communications receiver. Design and construction of a multi-band R.F. tuner covering 550 to 16,000 k/c.
—**Radio News (U.S.A.), October, 1948, p. 49.**

VALVES:

The infra-red image converter tube. Concluding article. Details of tube used in naval receiver for beacon detection; ancillary equipment; services' applications.
—**Electronic Engineering (Eng.), October, 1948, p. 314.**

Radio valve practice. Useful notes based on booklet issued by British Radio Valve Manufacturers' Association. Recommendations for obtaining optimum performance from valves.
—**Electronic Engineering (Eng.), October, 1948, p. 321.**

MISCELLANEOUS:

Design for a brain. The homeostat. Details of operation of a recent development which, although at present crude in form, shows promise of eventually being capable of performing many of the functions of the human brain. Makes use of negative-feedback and article amusingly describes higher-animal survival mechanism to operation of negative feedback.
—**Electronic Engineering (Eng.), December, 1948, p. 379.**

Frequency stability of diathermy units. Reference to factors affecting frequency stability in self-excited diathermy oscillator circuits. Circuit and design of 27.12 m/c. diathermy oscillator with power output of 300w. Plug-in monitor unit ensures operation within prescribed frequency limits. High-Q resonant circuit operates sensitive relay through a rectifier valve. When circuit is excited the cathode circuit of the oscillator is completed through the relay. Should oscillator frequency deviate from set limits, the voltage across monitor circuit decreases, the relay opens and cathode circuit of oscillator is broken. At the same time a buzzer warns operator of the condition.
—**Electronics (U.S.A.), December, 1948, p. 78.**

Melting-point chart. Thermometer-type graph, giving melting-points of metals, alloys, and ceramics most commonly used in electron tubes.—**Electronics (U.S.A.), December, 1948, p. 118.**

High voltage supplies for Geiger-Muller counters. Discussion of types, systems most suitable for portable counters. Curves given for typical operation under normal operating conditions.
—**Electronics (U.S.A.), December, 1948, p. 100.**

TRANSMISSION AND TRANSMITTERS:

Power amplifier for the citizens' transmitter. Circuit and construction of a two-stage power amplifier for use with transmitter previously described (**Electronics, November, 1947, p. 84**). Amplifier increases output of one-quarter watt to 10 watts. Consists of two stages of Class C grounded-grid amplification, using Type 2C43 valves. Cavity resonators and mounts are so designed that they may be constructed with hand tools.
—**Electronics (U.S.A.), December, 1948, p. 84.**

Scale distortion—again. An article clarifying the distinction between the decibel and the phon, intensity and loudness, and discussing the subject of scale distortion in audio amplifiers with reference to bass compensation.
—**Wireless World (Eng.), November, 1948, p. 392.**

Copenhagen frequency allocations. New European broadcast station wavelengths. Allocations in long (150-285 kc.) wave and medium wave (525-1605 kc. bands. To become operative, subject to ratification, on 15th March, 1950.
—**Wireless World (Eng.), November, 1948, p. 397.**

A Five-inch Oscilloscope Employing Unit Construction

PART 6 (Conclusion) DISTORTION MEASUREMENT

First of all, it is essential that the pattern used should be a simple line, and not a closed loop. For this reason, the measurement needs to be done at the frequency where there is no phase-shift. This is the reason for our having specified an oscillator whose frequency can be varied over a small range. The 'scope is connected exactly as for obtaining the phase-shift picture, as explained previously, the output going to the Y axis, and the input being connected to the X axis. The 'scope amplifier can be used for the horizontal deflection, since the input voltage will be very much smaller than the output voltage. Similarly, if the output voltage is too great, and swings the spot off the screen in the Y direction, a voltage divider may be used at the output so as to place only a fraction of the actual output voltage on the Y plates. The aim in adjusting the input amplifier and the output deflection is to obtain a picture in which the slope of the line is as nearly 45 deg. as possible, when the amplifier is delivering its full output. When this has been done, the input should be reduced to the point where the output voltage is about half the maximum. Then the oscillator frequency is adjusted until the pattern is a line instead of an ellipse. Now, the input is again increased until full output, or the maximum that can be reached without too much distortion, is attained. The pattern should then be something like the full line on Fig. 10. Next, with the amplifier still delivering its power, the input to the X axis is disconnected, and the Y deflection only is left on the screen. The position of the line is then marked on a piece of paper temporarily placed on the face of the tube. Without shifting the paper, the X input is again connected and the pattern is traced on the paper. We have now finished with the amplifier and the 'scope, and the rest of the process consists only in drawing some lines on the pattern which has been traced off, measuring various lengths, and working out the appropriate formulae, after these lengths have been substituted in them.

Working Out the Answers

The first step is to draw with a ruler a straight line between the ends of the input-output curve that has been traced from the screen. Next, the horizontal and vertical dotted lines shown on Fig. 10 are drawn in. The reason for disconnecting first the X and then the Y deflection voltages and drawing the positions of the remaining single deflections can now be seen, since these have to be used to show the directions on the paper of the axes of the graph. When the horizontal dotted line from the left-hand bottom corner has been drawn, it is divided into two and its centre marked "0" as in Fig. 10. A vertical line is then erected to meet the pattern and the straight line drawn between its ends. Then the distance between the point marked 0 and either end of the horizontal dotted line is called one unit for purposes of finding the positions of the other vertical lines. The first two are are at distances of 0.5 on either side of the point 0. The next two are at distances of 0.707 on either side of the same point, and the final one to be put in is one 0.3 to the right of 0. The ends, of course, are each 1.0 from the point 0. At all these points, vertical lines are drawn to cut the curve and the straight line joining its ends. The distances we want in order to apply the formula for finding the percentage harmonics are those between the arrows, labelled b, c, d, e, f, and g on Fig. 10. These six distances can be measured in tenths of an inch, thirty-seconds of an inch,

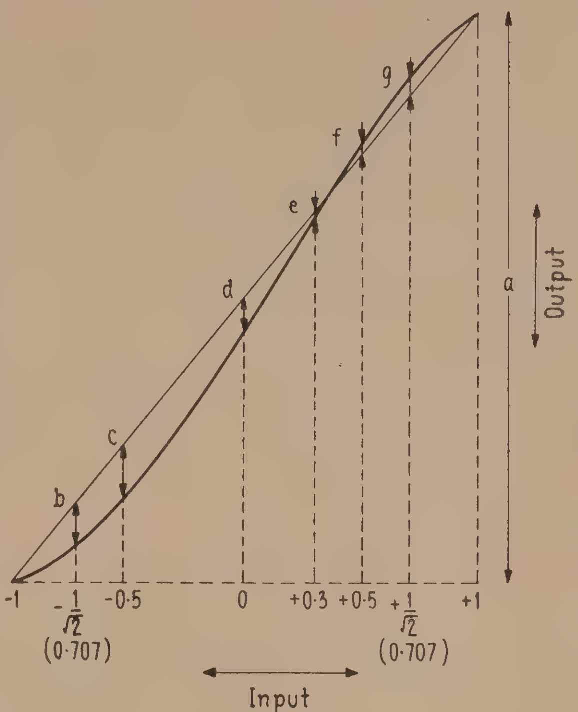


Fig. 10.

millimetres, or any other convenient unit, as long as all are measured in the same unit. It will be noticed that each distance is measured *along one of the vertical lines* and is the distance from the straight line to the curve. It is important to remember that distance measured *downwards* from the straight line must be called *negative,* and those measured *upwards* from it must be called *positive.* Thus, on Fig. 10, b, c, d, and e are all negative, while f and g are positive.

The formulae for finding the amplitudes of all harmonics up to the seventh are as follows:—

Second Harmonic:

$$V_2 = \frac{f+c}{3} + \frac{d-b-g}{4} = \frac{f+c}{3} + V_4$$

Third Harmonic:

$$V_3 = \frac{f-c}{3}$$

Fourth Harmonic:

$$V_4 = \frac{d-b-g}{4}$$

Fifth Harmonic:

$$V_5 = \frac{f-c}{3} + \frac{b-g}{2.828} = V_3 + \frac{b-g}{2.828}$$

Sixth Harmonic:

$$V_6 = \frac{d}{2} - V_2$$

Seventh Harmonic:

$$V_7 = \frac{(c - 1.82\,V_2 - 1.092\,V_3 + 0.655\,V_4 - 0.699\,V_5 - 0.751\,V_6)}{1.146}$$

Fundamental:

$$V_1 = a/2 + V_3 - V_5 + V_7$$

From an examination of the above, it can be seen that the minimum amount of working out is done if the harmonics are calculated in the order V_4, V_3, V_2, V_5, V_6, V_7, V_1, so that those which are used in calculating the others are worked out first. It is very seldom necessary to work out the seventh harmonic at all, and this is the only one which takes any amount of arithmetic. The answers for some of the harmonics will turn out to be negative, but this can be disregarded, *except when the figure is used in working out a further harmonic.* For example, in the case illustrated in Fig. 10, V_2 turns out to be -3.33, so that in finding the value of the sixth harmonic, we must put: $V_6 = d/2 - V_2 = d/2 + 3.33$.

It must be realized, too, that the numbers given by the formulae are not percentages, but only numbers, and that, in order to work out the harmonic percentages, a further small sum must be done. For example, for the percentage of second harmonic we have—

$$\text{Per cent. second} = \frac{100\,V_2}{V_1}$$

and for the third we have—

$$\text{Per cent. third} = \frac{100\,V_3}{V_1}$$

and so on.

All this takes considerable time and space to write about, but in practice it is very simple and easy to do, and gets results very quickly, especially if one does not want to estimate the higher harmonics. If the best accuracy is wanted, though, the formula for V_1, the fundamental amplitude, shows that the odd harmonics are needed. However, if one is interested only in second and third harmonic distortion, the fifth and seventh can be assumed to be zero, and unless by some mischance their amplitudes are considerable, this will lead to little error.

A last word about working out the results. Since the equations all use quantities which are the difference between much larger ones, it is advisable to work the calculations to two figures if the answer is to be correct to the first significant figure, and to three figures if an answer is to be correct to two figures. Needless to say, the whole thing means accurate tracing and measurement of the cathode ray tube pattern.

A Practical Beginners' Course

PART 30

The type of rectification given by a single diode is called half-wave rectification, because one-half of the current wave is completely lost. The practical circuit in Fig. 42 uses a double diode, each half of which performs half-wave rectification, in such a way that the half-waves cut off by one diode are used by the other, so that the output of the two is as in Fig. 43. This circuit is called a full-wave rectifier, and, as can be seen, acts to reverse the negative half of the wave instead of cutting it off altogether.

Comparing Fig. 43 with the upper half of Fig. 42, it can be seen that the output of the full-wave rectifier, though still not constant, is much more so than that of the half-wave type. For this reason, it is easier to smooth, which is why practically all sets and amplifiers use the full-wave circuit.

Practical Details

In Fig. 42 we have a power transformer. This is because the mains give us 230 volts, and the voltages we require are both higher and lower than this. For the heaters of the valves, we require 6.3 volts A.C., which is derived from this winding on the transformer and fed straight to the valve without rectification. For the high-voltage supply, we require a winding which has a tap at the centre. The tap is earthed, and each half of the H.T. winding gives us 320 volts A.C. Each end of this winding goes to one of the plates of the double diode rectifier. In our circuit the latter type is a type 6X5-G, which itself has a heater and a cathode. The rectified A.C. is taken from the cathode and fed through the smoothing filter, after which the irregularities will be absent, giving us a high D.C. voltage comparable to that of a bank of batteries. The tapped resistor across the output of the filter is known as a bleeder resistance, and is used to prevent damage to the power supply should it be turned on with no other load connected to it. The bleeder also acts as a voltage divider, for it is the type of resistor that has adjustable bands which may be set to give any voltage from 0 to the maximum provided by the power supply. On the circuit we have shown three taps which are set to give 250 volts, 100 volts, and 45 volts respectively. These values are chosen because all the valves liable to be used in small receivers have a maximum plate voltage of 250, require a screen voltage of 100, and if triodes are used as a regenerative detector, 45 volts. The condensers from the taps to earth should not be omitted, since they prevent a type of instability that does not occur when batteries are used.

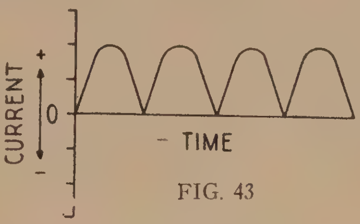


FIG. 43

This figure shows how two diodes in what is known as a full wave rectifier circuit make use of both halves of the A.C. cycle in producing a current that flows in one direction only.

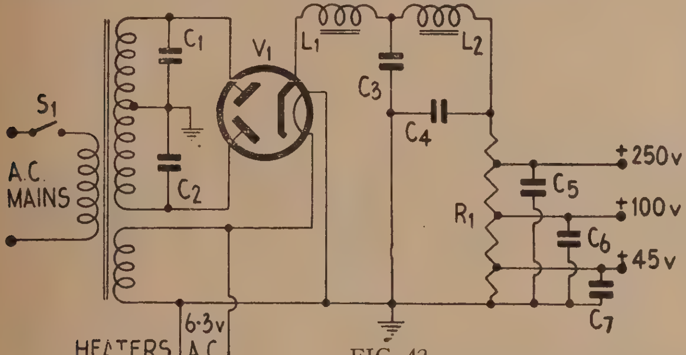


FIG. 42

C_1, C_2, 0.0001 μf. mica. 600 volts.
C_3, C_4, 8 μf. electrolytic.
C_5, C_6, C_7, 1 μf. 600v. paper.
R_1, 25k. 25 watts, with three sliders.
L_1, L_2, 40 ma. vibrator type chokes.
V_1, 6X5-G or GT.
Transformer, 320v.-a-side.
S_1, on/off switch.

Note: The negative terminals of C_3 and C_4 are earthed.

The lay-out of parts is not very important, but the supply should be built on a metal chassis. It is very important not to connect the electrolytic smoothing condensers the wrong way round, since this ruins them in about five seconds. The positive end is indicated in the tubular types by red paint, while with the can types, the insulated centre conductor is the positive terminal.

The 40 ma. vibrator chokes in the filter have been specified, because they are small and inexpensive, and quite satisfactory as long as the total current taken from the power supply does not exceed their rating, which will be the case as long as a power tube is not used and only headphone operation is required.

Precautions to be Taken

A few words of warning are necessary to those building A.C.-operated equipment for the first time. The voltages inside the power supply are high enough to be dangerous. NEVER under any circumstances touch the inside when it is switched on. NEVER connect or disconnect the plug to the set when the power is on. NEVER adjust the voltage divider tappings with the power switched on.

(To be continued.)

PUBLICATIONS RECEIVED

Frequency Analysis, Modulation, and Noise, by Stanford Goldman. Publishers: McGraw-Hill.

This is an important book for those engineers who are concerned with radar, television, and, in fact, any branch of the radio field where there is a great deal of importance attached to the design of sensitive receivers. The triple title is apt to be a little confusing, since the commas are ours and do not appear on the cover of the book itself. At first, the connection between the three subjects may not be apparent, until it is realized that the first section of the book comprises a very thorough treatment of Fourier analysis. This really forms the theme of the book, as, in a sense, the subjects of modulation (in all its manifestations) and random noise are variations upon it. At any rate, the importance of frequency analysis is clearly brought out in the treatment, which, though largely mathematical, has its main emphasis on the solution of practical problems. In no sense is the volume preoccupied with the mathematics of the subject, for its own sake; the whole is an outstanding example of mathematics as the servant of technology.

The author, having dealt in Chapter I with the Fourier series in its different forms, goes on to treat in an illustrative manner such highly practical subjects as the full-wave rectifier, the estimation of the frequency components in the output of valves driven to saturation, and the generation of harmonics and sum and difference frequencies by non-linear devices. Chapter III deals with the Fourier integrals and their application to transient phenomena, and this leads naturally to a detailed consideration of further practical problems such as the behaviour of selective circuits in response to non-recurrent signals such as pulses, the relation between band-width and the detail which can be transmitted by system of limited band-width, and optimum band-widths for systems carrying pulses, with respect to the ultimate signal-to-noise ratio.

Perhaps the most valuable part of this book is the final section, from Chapter VI on, devoted to noise, its effects on the transmission of intelligence, and its calculation. This is the first time, to our knowledge, that this subject has been treated in a text-book. Much of the work involved was done as recently as during the last war, when extensive theoretical and practical investigations of the subject were carried out, in conjunction with a number of then secret projects. The writer was fortunate enough at that time to have seen many of the war-time research reports upon which this part of the book is based, and like many others who were in the same position, welcomes the publication of this extremely important work in a readily available form. In addition

some of the material presented has not been published previously, even in the technical periodical literature, and is original with the author. It is difficult to over-stress the worth of this section of the book to anyone who is interested in the design of radio receivers and high-gain amplifiers. It contains, as well as the derivations of many of the important results, all the information necessary for the calculation of signal-to-noise ratio, and, what is more important still, details of the new noise-factor method of measuring the noise performance of receivers. All the necessary information is given on the calculation of the equivalent noise resistances of the different types of valve used in receivers and amplifiers, and all the important sources of noise are dealt with in detail, not excluding that generated by the aerial itself—a source which often seems to be overlooked in other more condensed treatments we have seen.

Briefly, this is a book well up to the high standard set by the publishers, written by an acknowledged expert in the field, and excellently produced, with clear, easily-read type (especially in the mathematical portions), and a reasonable number of exercises entailing the use of the mathematical methods employed in the text. Even if one is not very mathematically inclined, it is eminently readable, and cannot fail to add to the reader's knowledge and understanding of the issues which are its subjects.

Television Production Problems, by John F. Royal. Publishers: McGraw-Hill.

As its name implies, this little volume is concerned, not with the electronic nature of television, but with the production of programme material. Here, in this country, the day seems yet far off when we can expect to see the first television broadcast, but that is not to say that no one here takes an interest in the subject. To New Zealanders interested in the technique of television, this book should give a good idea of the kind of work and the extent of the resources necessary to turn a mere collection of television circuitry into an entertainment system. Just as few people realize what a small part of an ordinary sound broadcasting system is the mere provision of technical facilities, so does the author show us how small a part is played by the technical equipment of a television station in comparison with the organization and effort that must go into the planning and production of television programmes.

The foregoing does not mean that the technical aspects of television are not given due credit for their own importance in the scheme of things. In fact, it is emphasized throughout that the success of television broadcasting depends very largely on proper co-operation between those responsible for the programme material and those responsible for the technical aspects of its presentation.

The material is non-technical in nature, but emphasizes the necessity for all those who work on any one aspect of production to have at least an elementary understanding of the principles of television transmission, so that the co-operation mentioned above can be a real one, and not in name only. There is to be found in the second chapter a brief but excellently-written non-technical description of the salient features of the telecasting process, from the camera to the receiving cathode ray tube, and the whole volume makes an excellent exposition for the

(Concluded on page 45.)

Some Unusual Shortwave Aerials for Transmitting and Receiving

The folded dipole antenna is well enough known these days, and has found a great deal of use in commercial as well as in amateur aerial practice. The aerials described in this article, however, are not so well known, and form a useful addition to existing types. They have the advantage over ordinary folded dipoles in that a type can be chosen from them which will match a feeder of different characteristic impedance from the usual 300 ohms, and which will work without excessive standing wave ratios over a range of feeder impedances.

INTRODUCTION

The folded dipole owes its usefulness mostly to the fact that, unlike an ordinary single-wire dipole (or half-wave aerial, which is the same thing), it has an input impedance at the centre of very nearly 300 ohms. A single-wire half-wave aerial, when fed at the centre, has an input impedance in the region of 72 ohms, the exact value depending, among other things, on its height above the ground. This is one of Nature's awkward manifestations, inasmuch as it is inconvenient to try and make open-wire lines of this order of impedance. In fact, a practical lower limit for open-wire lines is in the region of 200 ohms, below which the spacing becomes inconveniently small compared with the diameter of the wire. However, if instead of a single-wire dipole we take two wires, each approximately half a wavelength long, and connect them as in Fig. 1 (a), we have an aerial which has all the normal characteristics of the single-wire dipole, except that its input impedance is something like four times that of the single-wire version. This gives us a figure of 288 ohms for the aerial of Fig. 1 (a), which is the type commonly called the folded dipole. A 288-ohm open-wire line is easy enough to construct, and the figure is so near to 300 that it is possible to use a standard 300-ohm line with so small a mismatch as to be unimportant. It is possible, also, by using different diameters for the two wires of the aerial, to obtain other step-up ratios. In fact, by adjusting the diameters and the spacing, it is possible to match the aerial to a wide range of line impedances. This is very nice in theorv, but except at V.H.F., where the "wires" can be made of rigid rods or tubes without difficulty, it is difficult to put into practice. For this reason, the aerials illustrated here are of considerable use to amateur transmitters and others, because they can be made from ordinary aerial wire, all of it of the same diameter, thereby simplifying the construction to the point where they are worth while looking at from the practical point of view.

All the aerials described were first published by J. D. Kraus in the January, 1940, issue of "Electronics," and the curves given later in this article are those given by him in the original article.

TYPES ILLUSTRATED

In Figs. 1 and 2 are illustrated five of the aerials described by Kraus in the above-mentioned article. Fig. 1 (a), as has already been pointed out, is the ordinary folded dipole, with both wires the same size. Its nominal length is half a wavelength, but the actual length of the wires that is recommended is 0.49 of a wavelength, or 0.49λ. The dimension, d, which is the centre-to-centre spacing of the wires, is not critical, and for all the aerials mentioned can be taken as 0.01 of a wavelength. This gives a spacing of 31.5 inches for the 80m. band, with corresponding reductions for the higher-frequency bands. It will be noticed that the spacing is somewhat larger than is commonly used to-day for folded dipoles. The result of this is that the input impedance, and therefore the line impedance that gives a match to the centre of this aerial, is 350 ohms, which is rather higher than the figure for the closer-spaced aerial. In Fig. 1 (b) and (c), we have two aerials whose input impedance is higher still. Fig. 1 (b), which is also nominally half a wavelength long, makes a direct match for 875 ohms, while Fig. 1 (c) matches an impedance of 1500 ohms.

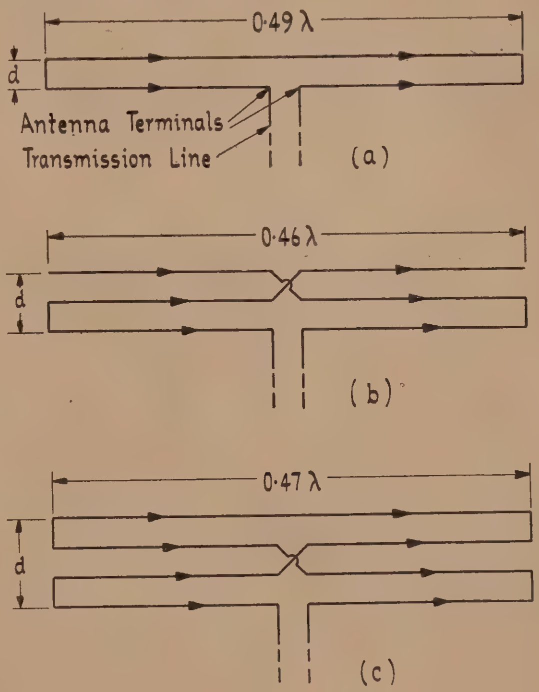


Fig. 1

These figures would seem to indicate that these two later types are not of much use practically, since it is not usual to construct open-wire lines with characteristic impedances as high as 875 or 1500 ohms, but this is far from being the case.

FEEDING PARASITIC ARRAYS

One of the difficulties of directional arrays is that very often they are even more inconvenient to feed, because their input impedance is much less even than

an ordinary half-wave dipole's. Even a simple Yagi consisting of radiator, one reflector, and one director, has a very low input impedance, with the result that it is necessary to use some sort of matching device to enable the radiator to be fed from a line of 300 to 600 ohms characteristic impedance. In cases like this, the radiator itself can be made to act as its own step-up transformer, by making it in one of the forms shown in Fig. 1. Consider the four-wire arrangement of Fig. 1 (c). A single-wire dipole has an input impedance of 72 ohms. This four-wire dipole of Fig. 1 (c) has one of 1500 ohms, so that, when compared with an ordinary dipole, it can be said to act as a transformer giving an impedance step-up

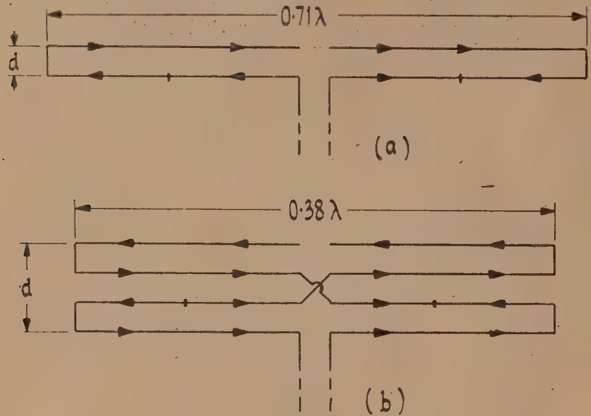


Fig. 2

of 1500/72 = 21 times, nearly. Now, the three-element beam, mentioned a few sentences back, has an input impedance of approximately 8 to 10 ohms, according to figures that have been published previously. Thus, if the radiator were made the four-wire dipole of Fig. 1 (c), instead of a single-wire dipole, the input impedance could be expected to be from 160 to 210 ohms. It seems likely that the actual figure would be even higher than this, in view of work done on parasitic arrays during the late war. This work indicates that the figure quoted above for the input impedance of the three-element parasitic array is too low, and that workable input impedances of the order of 300 ohms are obtained even when the radiator is made a simple folded dipole, as in Fig. 1 (a). If this was the case, then the aerials of Fig. 1 (b) and (c) would enable even higher feed-point impedances to be reached, so that it seems not unlikely that the 600-ohm line so common in amateur practice would be quite suitable for feeding a three-element array whose radiator was the four-wire arrangement of Fig. 1 (c).

TWO OTHER ARRANGEMENTS

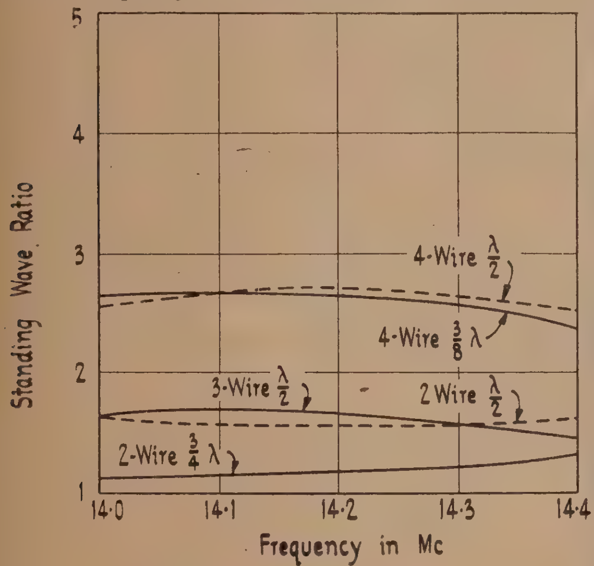
The remaining two horizontal aerials described by Kraus in his article are shown in Fig. 2. At (a) we have a two-wire arrangement which is a nominal three-quarter-wave long, and which should in practice be made 0.712λ. This aerial has an input impedance of 450 ohms.

A very useful one is that shown in Fig. 2 (b). This has four wires, but is attractive on account of the fact that it is nominally only three-eighths of a wave long. At the 80m. band, this means that a space of only 97 feet will accommodate the aerial

instead of the 125 feet needed for the half-wave single-wire dipole. This represents a saving of 28 feet, and may well make the difference between a shortened single-wire aerial, of doubtful efficiency, and a fully efficient aerial similar to Fig. 2 (b). The input impedance of this aerial is given as 230 ohms.

PERFORMANCE OF THESE AERIALS

The figures quoted here are those given by Kraus in the original article, and the graph, Fig. 3, is also from his results. These show that the aerials described are not nearly as critical as might be expected, in respect of their performance when fed from lines not of the optimum characteristic impedance. In order to show how non-critical they are, Kraus carried out experiments on all types illustrated, using a 570-ohm line in each case. Now, for some of them, this represents a considerable mismatch, and particularly in the case of the four-wire aerials, it can be expected to give appreciable standing waves on the feeder line. Fig. 3 shows the results that were obtained. In the tests, the aerials were all made of the correct length for the centre of the 40m. amateur band, so that the curves in Fig. 3 take into account not only the feeder mismatch, but also the fact that the aerial length was not adjusted as the frequency was varied over the band.

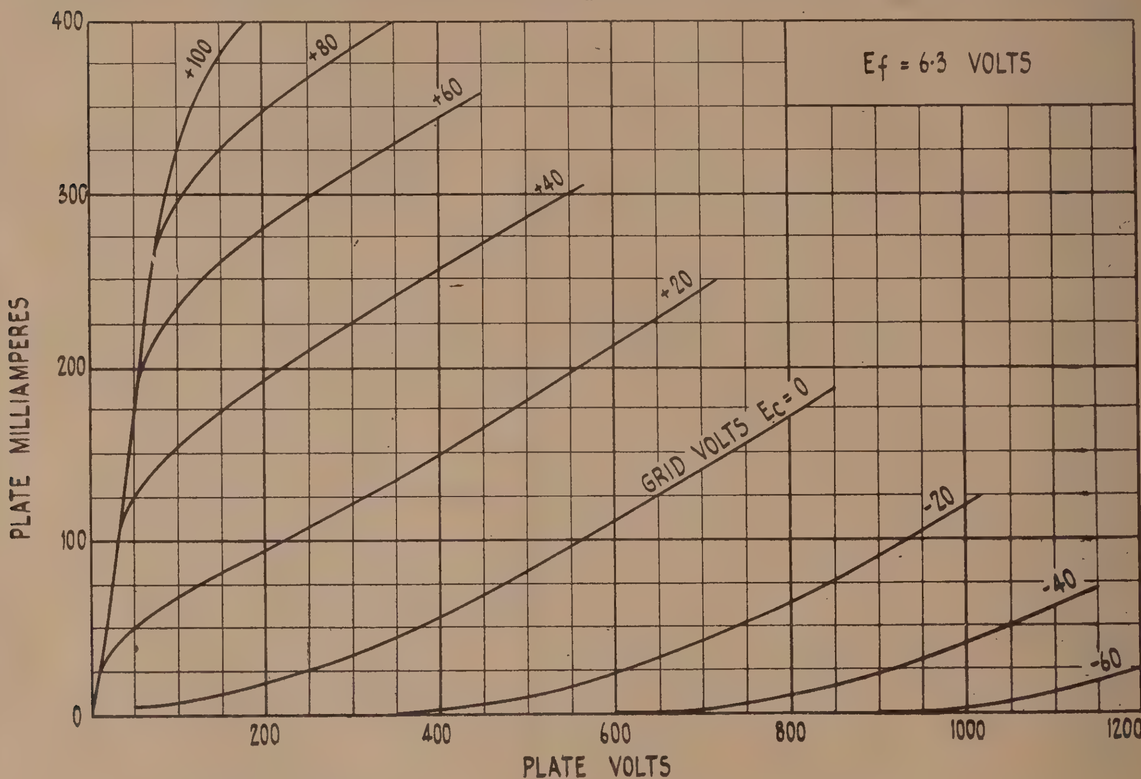


As might be expected from the figures already given, the aerial which behaved best with a 570-ohm line was the three-quarter-wave two-wire one of Fig. 2 (a). Here, the standing wave ratio was found to be about 1.21 to 1—a figure that is it quite unprofitable to try and improve upon. Furthermore, the standing-wave ratio was remarkably constant over the band, which is a very important feature, since no one wants an aerial which is inefficient at some parts of the band over which it has to work. It is very noticeable that in all cases, including the worst, the standing-wave ratio varies only very slightly over the band, so that it can truthfully be said that all these aerials are equally efficient at all parts of the band for which

(Concluded on page 45.)

TUBE DATA: THE 8012 V.H.F. TRANSMITTING TRIODE

The 8012 is a V.H.F. triode designed for use as an oscillator, R.F. power amplifier, and frequency multiplier for frequencies up to 600 mc/sec. Its maximum rated plate dissipation is 40 watts, and it can be operated at full ratings up to 500 mc/sec., and with reduced ratings up to 600. It is available in this country at a price well within the reach of the amateur transmitter, and appears to be the ideal tube for medium or even low-power working on the 420 to 460 mc/sec. amateur band, and also, of course, on the 144 mc/sec. band

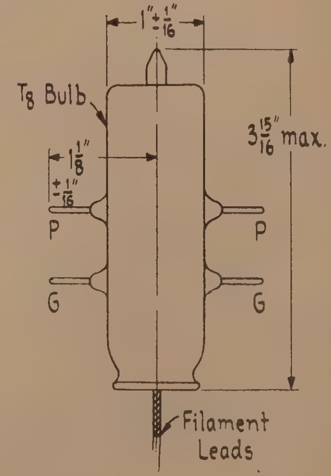


Construction

As might be expected, this tube is somewhat unusual in construction, having the shape and dimensions given in Fig. 1. It requires no base, and, as it is very light, it can easily be supported in parallel-line structures such as are used at the higher frequencies. It has two plate and two grid leads, which can be connected in parallel to reduce the lead inductances at high frequencies, and its mechanical design lends it very readily to certain specific types of line-controlled oscillator and amplifier circuit.

It also has three filament leads, which can be bypassed to one another, and therefore connected in parallel for R.F., thereby reducing the inductance of the filament circuit—which is important at the highest frequencies at which the tube will work.

It should be remembered that the ratings and typical operating conditions given in the tables below are *maximum* ratings, and that there is no reason at all why the tube cannot be operated at lower plate voltages and power inputs. In fact, contrary to many transmitting tubes which can have H.T. voltages up to 1000v. applied to them, this one operates particularly well with as little as 300 or even 250 volts on its plate.



Filament Operation

The manufacturers recommend that the three filament leads should be connected in parallel through small mica condensers, and that the centre-tap should be grounded *not directly,* but through a third condenser. The reason for this is that the D.C. plate current should not be allowed to flow through the filament centre-tap, as it would if these were directly grounded. Instead, the filament winding of the power transformer should either be centre-tapped or should be earthed via the common connection of two resistors in series across the filament supply. This is illustrated in Figs. 2 (a) and (b).

In Fig. 2 (a) is shown the necessary connection if the filament is to be earthed, and the position which the key should occupy, if the stage is to be keyed. In Fig. 2 (b) is shown the connection for the case (often found in V.H.F. oscillator circuits), where the filament is required to be above ground to R.F. The size of the R.F. chokes will, of course, depend on the operating frequency.

Application

We hope in an early issue to describe some suitable circuits for operating the 8012 up to at least the 450 mc/sec. band, under various conditions. This valve would make an excellent self-excited oscillator on this band, both for transmitting and for experiments with aerial arrays. The latter, whatever their configuration, can be scaled down to a frequency of 450 mc/sec. or so, and this valve will make an oscillator on that frequency of sufficient power output to enable polar diagrams to be drawn with the aid of a simple field-strength indicator, and for other measurements to be made on the experimental aerial systems. Such data can be taken to illustrate exactly the performance of exactly similar aerials, scaled up for use at lower frequencies. Experimental work carried out in our own laboratory has already shown that with only 400v. on the plate, the 8012 can give an output of several watts even as high as 500 mc/sec.

Ratings

Filament Voltage (A.C. or D.C.)	6.3 Volts
Filament Current	1.92 Amperes
Amplification Factor	18
Direct Interelectrode Capacitances:	
Grid Plate	2.8 μμf.
Grid Filament	2.7 μμf.
Plate Filament	0.35 μμf.

Max. Ratings and Typical Operating Conditions

RCA-8012 as R.F. POWER AMPLIFIER—CLASS C

	Plate Modulation	*C.W. or Oscillator*	
D.C. Plate Voltage	800 *max.*	1000 *max.*	volts
D.C. Grid Voltage	–200 *max.*	–200 *max.*	volts
D.C. Plate Current	65 *max.*	80 *max.*	ma.
D.C. Grid Current	20 *max.*	20 *max.*	ma.
Plate Input	33 *max.*	50 *max.*	watts
Plate Dissipation	27 *max.*	40 *max.*	watts
Typical Operation:			
D.C. Plate Voltage	800	1000	volts
D.C. Grid Voltage:			
from a fixed supply of	–105	–90	volts
or from a grid resistor of	10000	6400	ohms
or from a cathode resistor of	—	1400	ohms
Peak R.F. Grid Volt.	145	130	volts
D.C. Plate Current	40	50	ma.
D.C. Grid Current (approx.)	10.5	14	ma.
Driving Power (approx.)	1.4	1.6	watts
Power Output (approx.)	22	35	watts

(2) CHARACTERISTICS OF THE LOKTAL OUTPUT BEAM POWER AMPLIFIER TYPE 7C5

Since Loktal tubes are becoming available in this country, at least from one manufacturer, and because they are now being produced not only by American, but also by English manufacturers, we are presenting in our Tube Data section the characteristics and curves of the most important valves in this series. We trust that the data will be of use to manufacturers ,servicemen, and amateurs alike.

APPLICATION

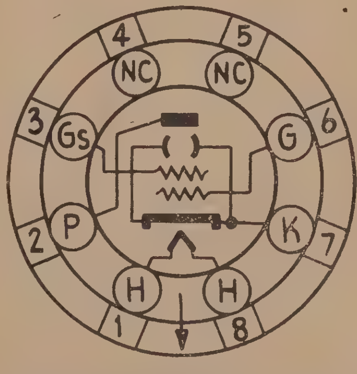
The 7C5 is a beam power tetrode intended for use in the audio power output stage of receivers using the Loktal series of valves. Its electrical characteristics are identical with those of the 6V6, so that there is no need here to print the detailed operating conditions for this type. Like the 6V6, this valve is capable of an audio output of 4.5 watts with 250 volts on plate and screen, a bias resistor of 250 ohms, and a plate current of 45 ma. The maximum plate and screen voltages are 315 and 285, respectively, as for the 6V6.

A point about the Loktal series is that, although their normal heater voltage is 7 volts, as shown by the type numbers. In practice, they are run from a heater supply voltage of 6.3v. A.C., in the same way as the normal series of 6.3v. valves.

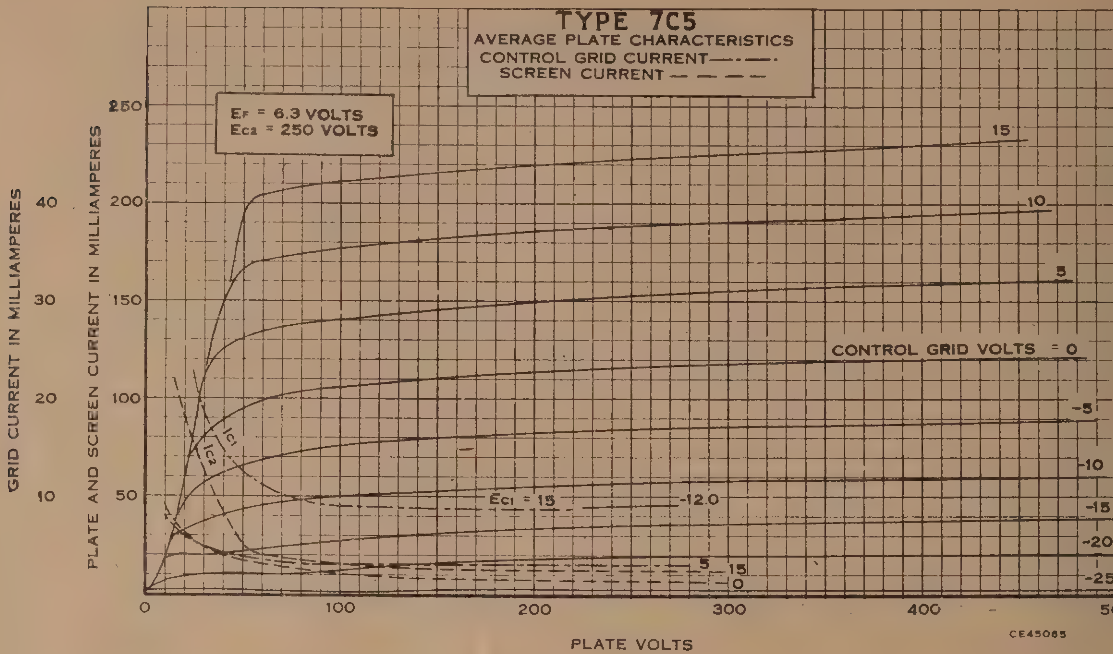
At the left are shown the electrode arrangement and the base connections for the 7C5.

DIMENSIONS

The maximum seated height of the valve is 2⅝ in., and the overall length, from the top of the bulb to the bottom of the locating spigot, is 3 5/32 in. The valve may be mounted in any position.



Electrode arrangement and base connections of the 7C5. For curves please see over page.


TYPE 7C5
AVERAGE PLATE CHARACTERISTICS
CONTROL GRID CURRENT
SCREEN CURRENT
EF = 6.3 VOLTS
Ec2 = 250 VOLTS
CONTROL GRID VOLTS = 0
15
10
5
-5
-10
-15
-20
-25
Ic1
Ic2
Ec1 = 15
-12.0
GRID CURRENT IN MILLIAMPERES
PLATE AND SCREEN CURRENT IN MILLIAMPERES
PLATE VOLTS
0
100
200
300
400
500
10
20
30
40
50
150
250
CE45065

Voltage Relations in a Class C Amplifier Stage

This simple exposition of the voltages to be found in the circuit of a Class C amplifier under signal conditions helps towards a fuller understanding of what can and cannot be done in practice.

CLASS C OPERATION

In reality, the operation of a Class C amplifier is a very complex matter, and a good many of the best brains in the radio engineering world have been racked over providing, for all to see, complete explanations of the behaviour of the circuit. The results of all this work are unfortunately couched in mathematics which are well beyond the scope of the average man, and, in addition, simplifying assumptions have had to be made in order to do even this, so that as far as most users of Class C amplifiers are concerned the subject boils down to using the conditions set out by the valve manufacturers and hoping for the best. In many cases, this process works out quite well, but when the complications inherent in drawing off the generated R.F. power and in supplying R.F. power to the grid circuit in a suitable way are added, there are so many variables that almost anyone can be forgiven for not realizing very well just what is going on in the circuit as a whole (i.e., from driver plate circuit to aerial output circuit) and for sometimes being unable to get the expected results.

The latter question is of extreme importance in high-powered commercial equipment, where any loss of efficiency is paid for in far from negligible sums of money, but in low-powered equipment, such as is operated by amateur transmitters, low efficiency can sometimes be disregarded from the cost angle. This is not to say that efficiency in Class C amplifiers and frequency multipliers does not matter at all, for no one wants unreliability, and yet this is often the result. For example, take a Class C amplifier used as the final stage in a 100-watt transmitter. Very often, through improper attention to such things as the L/C ratio of the output tank circuit, it is found difficult to draw as much power from the amplifier as is expected. Another thing that can clearly cause a loss of power output is insufficient driving power, and an attempt is sometimes made to rectify the situation by increasing the drive. This may result in a slightly increased power output under the conditions mentioned, and so is left as a permanent adjustment, regardless, perhaps, of the fact that the manufacturer's grid current ratings are being exceeded. As a result, excessive grid heating takes place, and the operating conditions do not remain stable. In the long run, there will often result a partial or complete tube failure, and almost certainly in erratic behaviour before this.

ACTION AT DIFFERENT PARTS OF THE INPUT CYCLE

The Class C amplifier is often described in the literature as a kind of modification of the Class A amplifier. It can certainly be looked upon in this way, but doing so does not lead to a very great understanding of its action. Let us see, then, whether there is not a more suitable way of looking at it.

First of all, it will be necessary to detail the most important simple facts about it These are as follows:

(1) The D.C. grid bias is considerably more than is required to cut off the plate current, considering the D.C. plate voltage that is used. Thus, if the input signal is not applied, the plate current would be zero.

(2) When an input signal is applied and gradually increased in voltage from zero upwards, no plate current will flow until the positive peak of the input voltage reaches into the range of grid voltages in which the valve is able to pass some plate current.

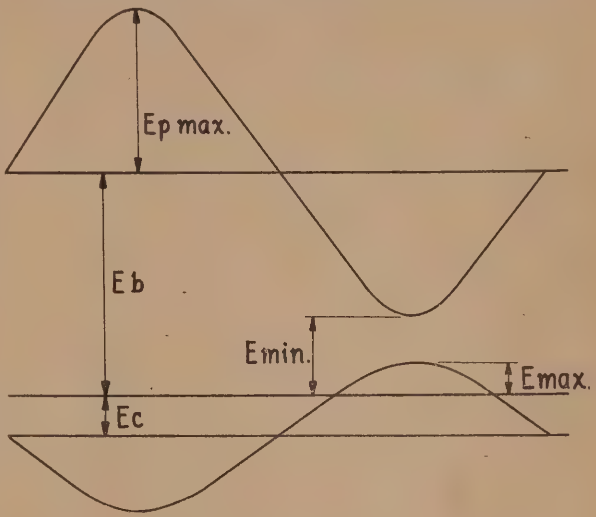


Fig. 1

(3) During the negative half-cycle of the input voltage, the valve cannot possibly pass plate current, since this half-cycle only makes the grid more negative than it already is—and, for a start, this is beyond cut-off, as stated in (1) above.

(4) When the input voltage swings the grid more positive in potential than the value of the cut-off bias, but less positive than zero bias, plate current will flow during that part of the positive half-cycle which brings the grid voltage between these limits, but no grid current will flow.

(5) When the input voltage is increased still further, so that the "tip' of the positive half-cycle drives the grid positive, grid current will flow, but only during that portion of the cycle in which the grid is positive.

(6) Similarly to any other amplifier, the plate voltage will be exactly in anti-phase with the grid voltage. That is, when the grid is most positive, the plate voltage will be most negative, and vice versa

(7) No. 6, above is true only because there is a load in series with the plate of the valve. In this case, the load consists of a parallel-tuned circuit, resonant at the frequency of the grid input voltage, but this fact in no way alters the fundamental relationship, which is true of all amplifiers which have a resistive load of any sort in the plate circuit. At the tuned frequency of the plate tank, as it is called, the circuit behaves as though it were a pure resistance.

(8) Because the load IS a tuned circuit, it can

never have anything but a sine-wave of voltage across it, at the frequency to which it is tuned.

All these eight points are simple properties of the circuit (because we have made it so) or of the valve.

As a direct result, the voltages in the circuit are as drawn in Fig. 1. If this is examined, some of its features will be obvious, from a consideration of points 1 to 8, of which it is merely a graphical illustration. On Fig. 1 are to be found three horizontal lines. The middle one of these represents earth potential, and all other voltages are represented by vertical distances, either upwards or downwards from it Distances upwards represent positive potentials, and downwards, negative ones The upper horizontal line is at a height E_b above, where E_b is the D.C. plate voltage on the tube. Similarly, the lower horizontal line is at a distance E_c BELOW, where E_c is the value of the D.C. grid bias. The input signal is represented by one cycle of a sine-wave, drawn about the bias line as axis, and points on this sine-wave tell us the momentary, or instantaneous grid at any part of the input cycle. Only one cycle is drawn, because the behaviour on all cycles is exactly the same. Distance **along** the horizontal line, from left to right, represent **time,** the starting-point being arbitrarily chosen as the time when the input wave crosses the zero line, and at which, momentarily, the input voltage is zero.

The first thing to note is that at this time, the plate voltage is equal to the D.C supply voltage. These things are only to be expected. An immediate difficulty in making this diagram mean something is shown in the first half-cycle of the grid voltage. This is a negative one, during which the plate current might be expected to be zero and the plate voltage no higher than E_b, the D.C. supply voltage. Actually, the diagram shows the plate voltage as considerably higher than the D.C. value. This simply serves to illustrate what we said above about the difficulty of interpreting Class C action in terms of diagrams similar to the ones which explain the Class A amplifier so nicely. The difficulty is really only due to the fact that we have taken one cycle of the input voltage out of its context, as it were, forgetting that, because the digram does not show the previous R.F. input cycle, such a cycle actually happened The apparent misbehaviour of the plate voltage during the negative half-cycle of input voltage is due to the fact that **the previous half-cycle was a positive one,** just like the one shown in the right-hand half of the diagram. Let us look at this half-cycle and see if it gives us a clue as to the seemingly peculiar behaviour during the negative one.

THE POSITIVE HALF-CYCLE

If points No. 4 and No. 5 above are considered, it is clear that the plate of the valve passes current only during a small portion of the positive half-cycle of grid voltage, and therefore during an even smaller proportion of the whole input cycle. This is simply another way of saying that the grid voltage acts as a switch, which turns the plate current on and off for a short time, every so often. How often, of course, depends solely on the frequency of this input voltage. On what, then, does "how long" depend? A glance at the diagram will clear up this point very quickly. Suppose the available input voltage is that represented on the drawing, and that all we can do to alter the operating conditions, as far the grid circuit is concerned, is to alter the D.C. bias. If we increase this, so that the lower horizontal line representing it becomes lower still, then the positive half-cycle will be lowered, too, and the tip will not extend to such a positive potential. Thus, the point at which the grid voltage crosses the zero bias line will occur later in the cycle, and the one at which it again drops below zero will occur earlier All told, then, the time during which the grid is positive will be shorter than before we increased the negative grid bias. Actually, the valve begins to conduct **before** the grid voltage gets to zero, but, in order to simplify the diagram, we have not shown the line representing cut-off bias. This lies between the actual bias and the zero bias lines. In short, increasing the bias while leaving the signal voltage unchanged, results in a shorter conduction period. On the other hand, decreasing the negative bias lengthens the period during which the plate current flows.

The behaviour of the plate voltage can now be tackled. We have to remember that the load in the plate circuit is a tuned circuit. Now, it is well known that if a tuned circuit is given a "kick" of voltage, the circuit oscillates, and that the oscillations gradually die down to zero if no further kicks are provided. Furthermore, the voltage across the tuned circuit is of a sine-wave shape. In our Class C amplifier, the tuned circuit in the plate gets a kick once in every cycle of the input voltage, which has the same frequency as the one to which the plate circuit is tuned. There is thus no chance at all of the oscillation in the tuned circuit dying away before the next kick comes along. Consequently, the wave-shape of the output voltage, viz., that across the plate tank circuit is sinusoidal. Further, as can be expected, there will be the greatest voltage drop across the tuned load circuit at the same time as the valve is passing its heaviest current. This is at the point where the grid is most positive, or, in other words, at the positive peak of the input voltage. Because the frequency of the two waves, input and output, is the same, the positive peak on the plate waveform must coincide with the negative peak of the grid waveform. The apparently peculiar behaviour of the plate waveform is thus explained.

THE EFFECT OF OPERATING CONDITIONS

How, then, do different operating conditions affect the picture we have just given of the operation of the stage? For example, how does the load impedance affect things? What is the effect of altering the bias and the input, or excitation voltage? In a qualitative way, these things—and others, too—can be answered by a consideration of the same diagram, Fig. 1. A full description of the circuit obviously needs to illustrate the valve currents, as well as the voltages, but we have purposely left these out of the diagram so as not to confuse it. Some other questions that need to be answered are: What is it about the circuit that makes its efficiency greater than that of a Class A amplifier? How do the various operating conditions over which we can exercise control affect the efficiency and power output? Also, are the conditions for maximum power output and greatest efficiency the same, and, if not, why not?

These questions make quite a formidable array, so we shall proceed on our way and attempt to bring them all into our further explanation.

(To be continued.)

THE EDITOR'S OPINION

THE PLESSEY MIDGET INTERMEDIATE FREQUENCY TRANSFORMERS

Handed to us recently for our inspection were two samples of the Plessey midget I.F. transformers which are now available in quantity from the New Zealand agents, Turnbull and Jones, Ltd. These transformers are mounted in small aluminium cans measuring 13/16 in. square by 1½ in. high. The windings consist of two iron-dust cores of the totally-enclosed type, butted firmly against each other with fibre washers between, to give the correct spacing, and thus the right coupling coefficient. Firmly mounted at each end of the coil assembly are fibre end plates, held in place by two nuts, which thread on to the outside of two sleeves, attached firmly to the cores. The inside of these sleeves is also threaded, and each carries one of the shafts which operate the tuning slugs. At each corner of the end-plates is a minute riveted eyelet, through which pass heavy wires, soldered in place, whose job it is to act as supports for the fixed silvered mica tuning condensers. In addition, these wires extend for some two inches below the lower end-plate, forming the external leads to the windings. The whole is an extremely rigid assembly, which gives one considerable confidence in the mechanical and therefore the electrical—stability of the transformers.

MOUNTING

A very ingenious method of mounting to the chassis is used. The lower sleeve, in the centre of the end plate, is rather longer than its upper counterpart, so that it can extend through a 5/32 in. hole in the chassis, forming a single-hole mount for the unit. In addition to the necessary mounting nut, a very stout spring clip is provided. This is simply slipped over the mounting sleeve, as though it were an ordinary spring washer, and the nut attached and tightened. A further detail—but an important one—is the provision of a locating piece, just long enough to go through a ⅛ in. hole in the chassis, so as to give positive positioning of the transformer, and to prevent its turning on the mounting axis when the mounting nut is being tightened. Though this may seem a comparatively small point, it is an important one to those interested in quantity production, as it not only saves assembly time, but also prevents costly wiring mistakes in which leads are incorrectly identified.

The method used for attaching the fixed condensers, and, of course, the leads from the coils, is an excellent one, since the connecting wires are rigid enough even to prevent short-circuits between any of the connections and the case of the transformer; also, it is virtually impossible for any of the electrical characteristics to change on account of mechanical stress or vibration. For this reason these components are eminently suitable for applications such as in car sets, where movement and vibration are the rule rather than the exception, and where space is usually at a premium as well.

ELECTRICAL CHARACTERISTICS

Measurements were made by the dynatron method of the inductance, dynamic impedance, and hence the Q of the windings of the sample transformers. This method is believed by some engineers to be the most accurate way of measuring these quantities. The figures for the Q's of the individual windings were found to vary from 119 to 110 at a frequency of 465 kc/sec., which is approximately the centre of the tuning range provided by the slug adjustments. For a transformer of the small size of these ones, these figures are outstanding, especially in view of the fact that the units tested were chosen at random from stock, and not specially selected in any way. As an example of their constancy of characteristics, it may be mentioned that one of the transformers tested showed figures of 110 and 113 for the two windings.

Of course, in measuring the Q of each winding, the other was de-tuned by unsoldering its tuning condenser, so that the coupling between windings should not affect the result. A check on the same transformer with both windings tuned to the same frequency gave a Q of 55. This indicates that the coupling between the two windings was almost exactly critical, and, within the experimental error, this can be taken as being exactly the case. It is recognized that a transformer in which critical coupling is achieved represents the best compromise between band-width, on the one hand, and voltage gain on the other. A stage using such transformers can be expected to have the greatest possible gain, and a response curve with a flat top of appreciable width, and yet the possibility of the stage having undesirable peaks and/or valleys in the response is quite remote. Such is not the case where over-coupling is resorted to in an attempt to widen the frequency response, and it is often found, with such transformers, that it is virtually impossible to arrive at a proper response curve without the use of a frequency modulated oscillator and oscilloscope in the alignment. The fact that the tests gave the above result without connecting the transformer in an actual operating circuit showed that the manufacturers have rightly allowed for the slight extra damping, caused in practice by the input and output resistances of the valves and the loading of the detector. In other words, in a practical circuit of an I.F. amplifier, this additional damping would see to it that the actual co-efficient of coupling was slightly less than critical, thereby effectively guarding against accidental over-coupling, with its attendant alignment difficulties.

SELECTIVITY

In order to estimate the band-pass and adjacent channel rejection qualities of these transformers, an I.F. stage was constructed employing them, and after careful alignment, response curves were taken. The results were as in the following table:—

Band.	Response
4.0 kc/sec.	Flat
5.0 kc/sec.	3 db. down
6.5 kc/sec.	6 db. down
8.0 kc/sec.	40 db. down

From this it can be seen that the usual band-width as far as audio response is concerned is from zero to approximately 6500 c/sec., after which the skirt selectivity is very marked, giving extremely good attenuation to the adjacent channel.

SUMMARY

Taken from all points of view, these transformers showed themselves to be an excellent job, both mechanically and electrically. Their extremely high

gain and good selectivity and bandpass characteristics indicate that they are not only outstanding as miniature components, but able to compete more than favourably with many full-sized transformers. They can thus be strongly recommended not only for portable receivers but for any set where it is desired to conserve space without sacrificing performance in any way.

COMMUNICATIONS RECEIVER

(Continued from page 19.)

without any noise being heard, and that if noise can be heard with the set in this condition, then the signal-to-noise ratio is not high. *These ideas are completely erroneous.* If a set *can* have all gain controls set to the "flat-out" position without a good deal of noise being apparent in the output (when no signal is being received, of course), all it means is that the set has not enough sensitivity to take full advantage of the low set noise, or, in other words, of its good signal-to-noise ratio. Put differently, *it is no use building a set which is inherently quiet unless sufficient gain is present for noise to be heard at a fairly high level when the gain controls are at maximum.*

This dissertation has been included in this article in order to prepare the builder for the fact that this set has more than the average overall gain, as well as better-than-average signal-to-noise ratio. Because of the former, there will be a good deal of noise apparent in the output when both gain controls are turned full on. In fact, it is possible to produce a large noise output without the first mixer working at all, so high is the gain in the double I.F. channel. For this reason, it is best to work with the manual R.F. gain control and the audio gain control set in the following way. The audio gain control is set to about half-scale. Then, the stand-by switch is turned off, thereby cutting out the H.T. supply to the first oscillator and mixer stages. Finally, the manual R.F. gain control is turned so that the noise is just barely audible in the speaker. Now, when the stand-by switch is turned on, there will be plenty of sensitivity, without noise which enters via the power lines and is picked up by the double I.F. system being audible.

(The End.)

SOME UNUSUAL AERIALS

(Continued from page 36.)

they are cut. Next up the list come the two and three-wire half-wave aerials. In spite of the fact that these aerials should theoretically be fed from lines of 350 and 875 ohms respectively, both of them caused standing waves of only about 1.5 to 1 when fed by the 570-ohm experimental line. Again, this performance is such that any striving for a better standing-wave ratio would be a waste of time and effort. It is extremely doubtful whether other commonly used aerials such as the single-wire delta-matched dipole give a performance as good as this.

The greatest standing-wave ratio was shown by the four-wire arrangements of Figs. 1 (c) and 2 (b). Even here, the standing-wave ratio was found to be less than 3 to 1 at all parts of the band, and, although by no means perfect, this can be classed as quite satisfactory.

It should be remembered, however, that by using a line of the optimum characteristic impedance, type for type, the standing-wave ratio can be reduced to any desired degree, and that the loss of transmitted power caused when the standing-wave ratio of 2 to 1 or less is entirely negligible, and for all practical purposes can be disregarded, even when the power input is very low.

FOLDING A VERTICAL AERIAL

Another useful aerial described by Kraus, but not illustrated here, is the two-wire folded vertical aerial. This consists of two vertical wires, spaced by 0.01 wavelength or less, and joined together at the top, but not at the bottom. The feed is applied between the lower end of one wire and earth, while the second wire is insulated at the lower end. This aerial has an input impedance of 250 ohms, which is much higher than the 36 ohms shown by a single-wire quarter-wave vertical, but the most useful feature of this type is that its height needs to be only 0.38λ. Thus, for a non-directional aerial for 10m., the height would be only 13 ft. instead of 25 ft. 6 in. for the commonly used three-quarter-wave J type of aerial. It would also be just as efficient, as long as a good earth is available.

PUBLICATIONS RECEIVED

(Continued from page 33.)

interested layman or for those whose interest in the electronic side of the subject needs to be broadened by a knowledge of its production techniques. It will be found especially interesting by those already engaged in the production of programmes for sound broadcasting, showing, as it does, what will be expected of them and of other workers who have no counterpart in ordinary broadcasting, when the first television programmes are broadcast in this country.

Index to Vol. 3 of *RADIO & ELECTRONICS*